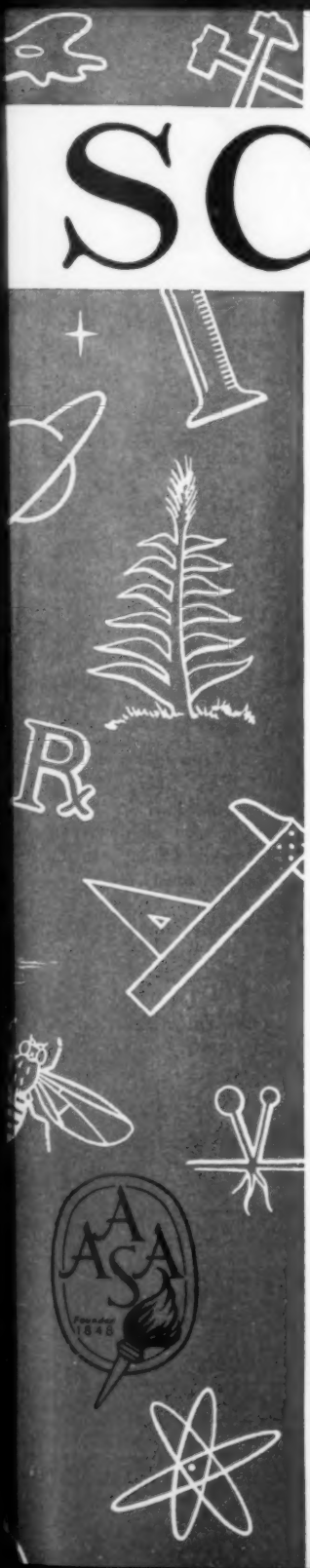

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SEPTEMBER 26, 1952

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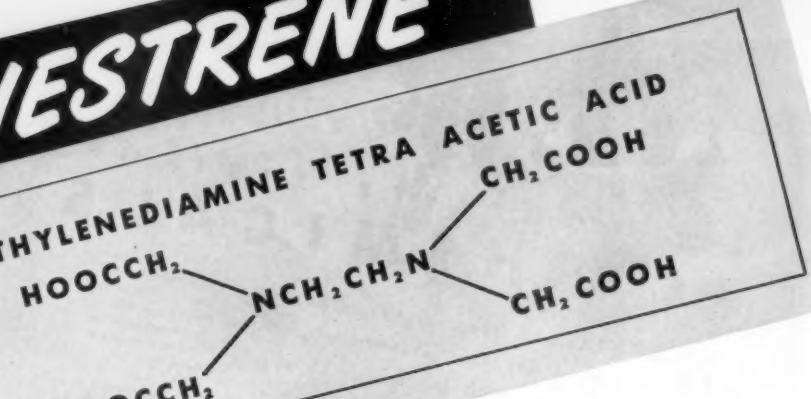

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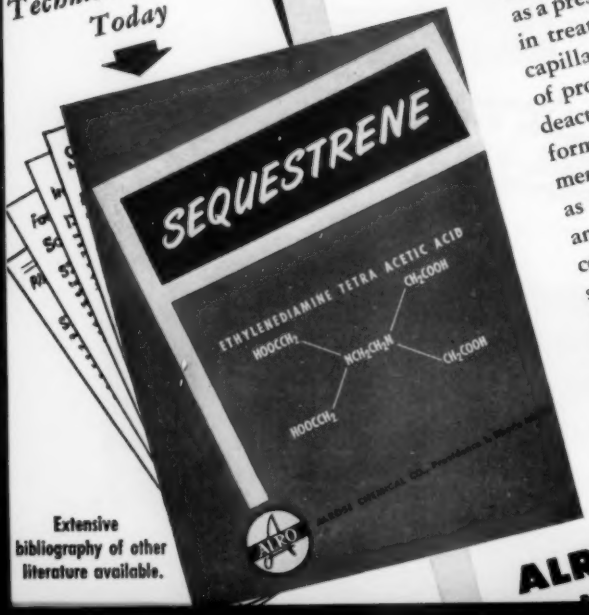

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This nonprofit organization serves industrial concerns and government agencies by acting as an extension of each sponsor's laboratory. Under the Armour Plan, a diverse professional staff systematically collaborates on individual projects, and because of this diversity increasing numbers of sponsors have found specialized research organizations such as the foundation both economical and effective for solving important research and development problems. The variety of scientific equipment and the range of scientific disciplines available increase the chances for research success. Such research projects as trace elements in meat, the flow of molten metal, palm oil substitutes, roller chains, corrosion of metals, and lightweight concrete aggregates will serve to give some indication of the breadth of the foundation's research effort.

The investigation of trace elements in meats is sponsored by a national business association interested in determining the mineral content of the various cuts and grades of beef, lamb, pork, and veal. The analytical tool used in this work is the emission spectrograph. The first phase of the program, recently completed, showed that beef, for example, contains some 20 trace elements, in concentrations ranging from about one part per billion to a few tenths of 1 per cent.

A theoretical and experimental exploration of the flow of molten steel through various gating systems used for production of steel castings has resulted in the development of a design theory that permits prediction of flows within about 5 per cent. The theory also permits calculation of mold-filling times within an accuracy required by the practical foundryman.

The search for a domestic product to replace palm oil in hot-dip tin plate manufacture has led to discovery of a promising new substitute derived from white grease, which may contain substantial quantities of pork fat. A substitute previously developed by the foundation uses beef tallow as a starting material.

Objective of the research on roller chains is the identification of certain basic factors and mechanical effects influencing chain life that will be useful in determining chain design, material specifications, and chain-drive capacities. In the initial phase of the program, instruments were devised for measurement of forces on chains in motion. A large chain testing machine also was built and used with the instrumentation.

The problem of corrosion of metals is being attacked from several points of view. Apparatus has been devised that gives a better insight into the manner in which metals corrode. Corrosion inhibitors for various applications are being tested. Several projects are concerned with development of lightweight aggregates for concrete mixes. Many raw materials and processing techniques have been examined, resulting in production of a number of aggregates combining light weight with strength.

This wide variety of investigations continually challenges and invigorates the staff. There is no time for stagnation when new demands are made each day on the foundation's capacity and on the ingenuity of its personnel.

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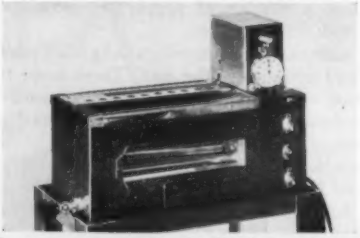

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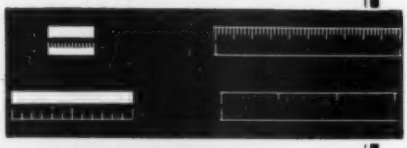

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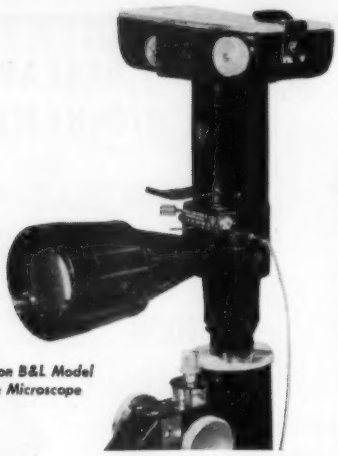

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Distributions of Ability of Students Specializing in Different Fields

Dael Wolfle and Toby Oxtoby

Commission on Human Resources and Advanced Training, Washington, D. C.

IT IS OF INTEREST TO KNOW how students who choose one field of specialization resemble or differ from those who enter another. It is now possible to compare different student groups in terms of their distributions of scores on standard tests of academic aptitude, for substantial data on this point have been developed by the Commission on Human Resources and Advanced Training in its studies of the current supply of people in each of the high-level fields of specialization and of students potentially qualified for work in those fields.

Table 1 gives test scores, converted to the Army General Classification Test scale, of students in each of a number of fields of specialization. On the AGCT scale the average person in the total population earns a score of 100. The standard deviation of the scale is 20 points, which means that 68 per cent of the total population makes scores between 80 (100 minus 20) and 120 (100 plus 20). Five scores are given for each field. These five represent the 10th, 25th, 50th, 75th, and 90th percentiles of each distribution. If there were 100 people in a group, and if they were lined up in order from the one with the lowest to the one with the highest score, the figures in the table would represent scores made by the 10th, 25th, 50th, 75th, and 90th persons in the line. For a single comparison of the fields, the 50th percentile, or median, score is the most useful. In each group half the members exceeded and half fell below this point. For most fields two, and for some fields three, sets of scores are given. The designation *AB* for a set of scores means that it applies to students who have recently received bachelor's degrees with major work in the field specified. The designation *graduate student* indicates scores for recently enrolled graduate students. The designation *PhD,* which appears only for some of the scientific fields, indicates the scores of students who have recently received doctorates.

Scores for the AB and graduate student groups printed in italics are weighted totals. The proportions of students in our samples who specialized in each field did not always match the total national proportions. In computing score distributions for total groups we weighted the separate fields in order to let each contribute to the total in proportion to the number of degrees currently being given in that field in the country as a whole. Table 1 therefore permits comparisons between general areas—e.g., natural sciences and social sciences—as well as comparisons between individual fields—e.g., chemistry and economics.

Before individual fields are discussed, it is worth while to compare the total groups with the general population. The average person earning a bachelor's degree scores about 126 on the AGCT scale. About 10 per cent of the total population earns a score this high. The average graduate student gets a score of around 129. About 7 per cent of the total population does as well. The average PhD in the sciences makes a score of approximately 138. Only about 2 per cent of the total population makes a score that high.

Students specializing in some areas make scores that average higher than the figures just given, whereas students specializing in other fields average lower, but all the groups are substantially superior to the total population. At the undergraduate level the difference between the highest field, physics, and the lowest, physical education, is less than the difference between physical education and the population average. At the PhD level, the spread between the highest field, physics, and the lowest, agriculture, is smaller than the difference between the average PhD in the sciences and the average AB.

Clearly, all the fields requiring college training attract students who average well above the general population. Yet there are consistent differences among the fields. In order, from top to bottom in terms of the median scores, students earning bachelor's degrees line up as follows: physical sciences (except chemistry), chemistry, engineering, law, English, foreign languages, psychology, economics, geology and the earth sciences, biological sciences, fine arts, nursing (nurses with AB degrees), history, agriculture, business and commerce, humanities (except English and the foreign languages), social sciences (except history and economics), education, home economics, and physical education. Students of physical sciences other than chemistry average two points higher than students of chemistry, the next field in line; and students of home economics and physical education are five and six points below students of education. In no other case is the difference between adjoining fields more than one point on the AGCT scale. The exact ranks, therefore, are not to be taken too seriously. Repetition of the study on a different group of students might well change some of the ranks, but it is unlikely that the changes would be very great. Standard deviations of the medians vary, but almost all of them are less than one.

Graduate students line up in approximately the same order. The largest change is for agriculture,

TABLE 1

APTITUDE TEST SCORE DISTRIBUTIONS OF STUDENTS SPECIALIZING IN DIFFERENT FIELDS OF STUDY

Field of specialization	Percentile scores (on AGCT scale) of each group				
	10	25	50	75	90
Natural Sciences					
AB	*114*	*121*	*128*	*135*	*143*
Graduate students	*118*	*125*	*133*	*140*	*147*
PhD (Including Agriculture, Engineering, and Psychology)	*122*	*130*	*138*	*148*	*158*
Chemistry					
AB	116	123	130	137	145
Graduate students	118	126	134	142	148
PhD	125	132	140	148	157
Physical Sciences, other					
AB	116	123	132	138	149
Graduate students	122	129	136	143	148
PhD	123	134	143	154	161
Earth Sciences					
AB	114	120	126	134	139
Graduate students	114	121	129	137	144
PhD	126	133	139	149	160
Biological Sciences					
AB	112	119	126	133	140
Graduate students	117	123	131	138	145
PhD	120	127	134	142	150
Psychology					
AB	113	119	128	135	142
Graduate students	123	130	137	143	149
PhD	125	133	142	155	163
Social Sciences					
AB	*110*	*117*	*125*	*132*	*139*
Graduate students	*114*	*121*	*129*	*138*	*145*
Economics					
AB	114	120	127	134	142
Graduate students	114	121	130	138	145
History					
AB	110	118	125	132	139
Graduate students	114	121	129	136	144
Other Social Sciences					
AB	108	115	123	131	137
Graduate students	114	121	129	138	145
Humanities and Arts					
AB	*113*	*120*	*127*	*134*	*141*
Graduate students	*115*	*122*	*130*	*139*	*146*
English					
AB	114	121	128	136	143
Graduate students	120	126	134	141	147
Languages					
AB	114	121	128	135	142
Graduate students	115	123	131	140	148
Philosophy and other Humanities					
AB	109	118	123	133	139
Graduate students	117	126	135	142	148
Fine Arts					
AB	112	119	126	132	140
Graduate students	112	119	126	135	143
Engineering					
AB	115	122	129	137	145
Graduate students	118	123	131	139	145
PhD	121	131	138	149	153
Applied Biology					
AB	*106*	*114*	*121*	*127*	*134*
Graduate students	*117*	*122*	*129*	*135*	*141*
Agriculture					
AB	114	119	124	130	137
Graduate students	121	127	132	138	144
PhD	113	121	130	137	144
Home Economics					
AB	100	110	118	124	130
Graduate students	110	116	121	127	130
Health Fields					
Graduate students	*116*	*123*	*130*	*137*	*144*
Medicine					
Medical school students	119	125	132	138	145
Dentistry					
Dental school students	112	118	126	134	142
Nursing					
AB	113	119	125	134	143
Other (Graduate students in all fields except Medicine and Dentistry)	116	123	131	138	145
Business and Commerce					
AB	111	117	124	131	137
Graduate students	112	119	126	133	140
Education					
AB	*105*	*114*	*122*	*129*	*135*
Graduate students	*112*	*119*	*126*	*133*	*138*
Education, general					
AB	107	116	123	131	136
Graduate students	113	119	127	134	139
Physical Education					
AB	99	110	117	124	134
Graduate students	108	115	120	125	129
Other Fields					
Law					
Law school graduates	117	120	129	133	140
Social Work					
Graduate students	112	119	126	132	138
All Fields Combined (weighted averages)					
AB	*112*	*119*	*126*	*133*	*140*
Graduate students	*114*	*121*	*129*	*137*	*144*

which moves up from fourteenth place on the undergraduate list to sixth place on the graduate list. Medicine, which is here classed with the graduate degrees, ranks in seventh place, between agriculture and engineering. Dentistry comes in sixteenth place, between education and business and commerce.

Our sample of people who have earned doctor's degrees is limited to students of the sciences. In chemistry, the earth sciences, engineering, physics, and psychology the distributions are much alike, with median scores ranging from 138 to 143. Students of the biological sciences average four, and students of agriculture eight, points below the general average.

There is overlapping among all the distributions. Students of the physical sciences are, in general, a superior lot, but some of them fall below the average student of home economics or physical education. Students in those fields are, in general, considerably less highly selected, but some of them score above the median student of physics.

Without exception, graduate students in a field are more highly selected than are undergraduates, but for some fields the differences are small. The median scores for AB's and graduate students in the fine arts are

exactly the same, but the 75th and 90th percentile points are a little higher for graduates. Only two points separate the two medians for engineers and for students of business and commerce. At the other extreme, the two medians for philosophy and the other humanities (excluding English and the foreign languages) are 12 points apart. In some fields the typical graduate student is clearly much more superior to the typical student earning a bachelor's degree than is the case for other fields.

The discussion so far has centered around the students who specialize in a particular field. It is also possible to study the way in which students of a particular level of ability divide up among the fields of specialization. How, for example, are the very best students distributed among the different disciplines? The earlier discussion has demonstrated that the general quality level differs from field to field. We know, too, that some specialties attract many more students than do others. A large field may therefore include numerically more of the top quality students than does a small field, even though proportionally it includes fewer. The top fifth of all graduate students, in terms of placement on the AGCT scale, divide themselves up as follows: 18 per cent major in one of the natural sciences, 6 per cent in psychology, 8 per cent in the social sciences, 14 per cent in the humanities and arts, 9 per cent in engineering, 2 per cent in agriculture, 7 per cent in medicine, 4 per cent in the other health fields, 3 per cent in business and commerce, 17 per cent in education, and 13 per cent in other fields. Every field draws some of the top quality students and thus includes some men and women who are able to exercise the kinds of intellectual leadership indicated by high scores on tests of general ability.

The top 10 per cent of graduate students in all but four fields (home economics, education, physical education, and social work) of the 24 listed in Table 1 score at 140 or above on the AGCT. A score of 140 is earned by less than 2 per cent of the general population. In nearly every field, therefore, 10 per cent or more of the graduate students come from the top 1 or 2 per cent of the population.

The fields differ considerably, however, in proportion of their membership composed of these intellectually most gifted students. For each top quality student (upper fifth of all graduate students) in the natural sciences there are two others of lesser endowment. For each one in the humanities and arts there are three of lesser ability. In the social sciences the top level people are each working with four of lesser ability. In physical education the very bright graduate students must be pretty lonely indeed; for every student from the top group there are some 35 from lower levels.

It is also of interest to know where the poorest quality of graduate students go. Again the answer depends partly upon the size of the field and partly upon its differential attractiveness to students of different ability levels. The combined result is of this order: of the bottom one fifth of all graduate students, in terms of the AGCT scale, about 6 per cent are in the natural sciences, 1 per cent in psychology, 6 per cent in the social sciences, 10 per cent in the humanities and arts, 5 per cent in engineering, 3 per cent in agriculture and home economics, 4 per cent in medicine, 5 per cent in dentistry, 1 per cent in the other health fields, 8 per cent in business and commerce, 46 per cent in education, and 6 per cent in other fields. There are many more graduate students in education than in any other field, but even so, one of the sad effects of the low salaries and low prestige accorded to the nation's school teachers is the fact that nearly half of the lowest fifth of graduate students in the country are working for advanced degrees in education. They will be guiding the development and influencing the career choices of the next generation of students.

In considering the data presented above it is necessary to ask how representative our samples are of all students in the country. No one knows the characteristics of the entire student population, so a precise statistical answer is impossible. All that we can do is to describe our samples.

Data on persons receiving bachelor's degrees came from a study of recent graduates of 40 colleges and universities. Each of these schools supplied to the Commission a number of items of information for each student who enrolled in the fall of 1946. (Some schools also supplied data on 1944 and 1945 entrants.) Approximately 10,000 of these students have since graduated, and they constitute the population at the bachelor's degree level upon which we have reported. The 40 schools were widely scattered geographically and quite diverse in type of control, size, and characteristics of their student bodies. Some had high admission standards and some rather low standards. A separate analysis of returns from the first 18 schools gave results substantially similar to the results for the entire 40.

For the study of graduate students the University of Washington in Seattle supplied scores on the Miller Analogies Test of all applicants for admission to the graduate school during 1950. The University of Pittsburgh furnished scores on the same test for all recipients of graduate degrees during the period 1949–51. The Psychological Corporation gave us the scores of small samples of graduate students from 40 other universities. When these three sets of scores were analyzed according to the major fields of study, the distributions were sufficiently similar so that the data from all three sources were combined to give a total population of approximately 4500 graduate students.

Records of students earning doctor's degrees came from a more limited study. The Office of Scientific Personnel of the National Research Council provided the names of men and women who have earned PhD degrees in the sciences since 1940. Those whose undergraduate work had been done in an Ohio or a Minnesota college were selected for study, because from those two states it was possible to get test scores and other background information from high school and

college years. Test scores were available for 1100 of the 1300 students included in this study.

Support for the assumption that our samples were reasonably representative comes from a comparison of our findings with other data. There have been scattered reports comparing the students in one field with those in other fields at the same college or university.

TABLE 2

Field of specialization	Median score of recent AB's (from Table 1)	Mean score of college seniors on SSCQT (converted to AGCT scale)
Physical sciences (including chemistry and earth sciences)	130	132
Biological Sciences	126	126
Social Sciences	125	128
Humanities	127	128
Engineering	129	132
Agriculture	124	122
Business and Commerce	124	126
Education	122	118
Total group	126	128

We have examined these reports and have also compared the data with analyses of the score distributions of students graduating with different majors during the past 30 years from the Ohio State University. The recently published analysis[1] of the scores made by different groups of students taking the Selective Service College Qualification Test makes it possible to compare our data with the scores of the 38,420 college seniors who took the SSCQT during 1951. Average scores for approximately comparable groups are given in Table 2.

The conversion of SSCQT scores to AGCT scores is an approximation; one column gives means and the other medians; the SSCQT sample consisted of a self-selected group of men, whereas our sample consisted of all men and women graduates from a selected list of colleges. Nevertheless, the agreement between the two sets of data, together with the other lines of evidence outlined above, indicates that the scores presented in Table 1 can be accepted as reasonably good estimates of the distributions of ability of students currently being trained in the United States for work in scientific and other fields of specialization. It seems reasonable to accept 126 as a fair estimate of the median score of graduates of colleges and universities. Other Commission data indicate, however, that if all types of degree granting institutions were included the median would be a few—perhaps five—points lower. But changing the estimated median would not affect the field-to-field comparisons. Those are so consistent from one set of data to another that they can be accepted with a good deal of confidence.

In conclusion, those fields which have reputations of requiring abstract and rigorous thinking (e.g., physics, chemistry, law) attract students who are, on the average, superior to those who major in traditionally "easier" subjects (e.g., business and commerce or education). But the distributions all overlap; every field attracts some of the mediocre students; every field attracts some of the brightest.

[1] *A Summary of Statistics on Selective Service College Qualification Test.* Statistical Report 52–1. Princeton, N. J.: Educational Testing Service (Jan. 22, 1952).

News and Notes

Scientists in the News

Nathan Birnbaum, associate professor of chemistry, has returned to the City College of New York after a three-year leave of absence, during which he was on active military duty as lieutenant colonel with the Chemical Corps, U. S. Army. Dr. Birnbaum will remain associated with the Chemical Corps as a consultant to the Research and Engineering Command, Army Chemical Center, Md.

Columbia University Engineering School's new Aeronautical Structures Laboratory has added **Bruno A. Boley** to its staff as associate professor of civil engineering. Dr. Boley goes to Columbia from Ohio State University, where he was in charge of the structures curriculum and research in the Department of Aeronautical Engineering.

Elias Cohen has been appointed instructor of pathology at the School of Medicine, University of Oklahoma, as well as assistant director of the clinical laboratories of the teaching hospital. He will extend the quantitative immunological studies that he was conducting at Rutgers University.

Horace C. Dudley, USN, has been relieved as head of the Allied Sciences Section, Medical Service Corps, by L. A. Barnes. For the past five years, Comdr. Dudley has also been chief of the Biochemistry Division, Naval Medical Research Laboratory, Bethesda, Md. His new assignment is as head of the Radioisotope Laboratory, U. S. Naval Hospital, St. Albans, N. Y.

Howard E. Evans, associate professor in entomology at Kansas State College, has resigned to accept a position at Cornell University, succeeding **J. C. Bradley,** retired (SCIENCE, **115**, 7 [1952]).

K. P. Ewing, who for 32 years has served as research entomologist with the USDA Cotton Insects

Division, has been chosen to coordinate the cooperative research programs of USDA and various states and other agencies set up to bring the pink bollworm under control. Named as special assistant to the leader of the division, Mr. Ewing will be responsible for all USDA cotton insect surveys and research in Texas and Oklahoma. The Oscar Johnston Cotton Foundation, Memphis, Tenn., is cooperating with the USDA in its efforts to develop more effective pink bollworm control measures, and Mr. Ewing will administer this cooperation as it relates to the Bureau of Entomology and Plant Quarantine.

Harold V. Gaskill has accepted the chairmanship of the Committee on Highway Safety Research of the National Research Council, succeeding **E. R. Hilgard,** dean of graduate studies, Stanford University, who has consented to remain a member of the committee. Dr. Gaskill is dean of the Division of Science and director of the Industrial Sciences Research Institute, Iowa State College, Ames. He is at present on leave in Washington, serving as chief scientist and deputy chief of research and development, Office of Chief of Staff, U. S. Army. **T. W. Forbes,** executive secretary of the committee, has resigned from his position as associate professor of psychology at the University of Hawaii, in order to continue in his present capacity with the committee and to accept the additional appointment as technical director.

Mead Johnson & Company, Evansville, Ind., have appointed **Ben King Harned** executive director of research, with responsibility for all laboratory activities of the company.

Two research chemists of the Corning Glass Works will be awarded John Price Wetherill Medals by The Franklin Institute for their discovery of a new process for manufacturing glass. They are **Harrison P. Hood** and **Martin E. Nordberg,** both of Corning. The Frank P. Brown Medal will be given to **Fred N. Severud,** of New York City, for his engineering accomplishments in the field of building construction; **Cyril Stanley Smith,** professor of metallurgy and director of the Institute for the Study of Metals at the University of Chicago, a former member of the Manhattan Project, will be awarded a Francis J. Clamer Medal for his metallurgical contribution to the development of atomic energy during and since World War II; **Alfred J. Buchi,** of Winterthur, Switzerland, an authority on Diesel engines will receive the George R. Henderson Medal; and **H. Birchard Taylor,** Philadelphia engineer and industrialist, will be awarded an Elliott Cresson Medal. Formal presentation of the medals and awards will take place at the institute's annual Medal Day ceremonies in Franklin Hall Oct. 15.

The David Sarnoff Gold Medal Award will be presented to **A. G. Jensen,** director of Television Research, Bell Telephone Laboratories. The medal, presented each year in recognition of recent technical contributions to the art of television by RCA's Chairman of the Board General Sarnoff, was instituted last year, when Otto H. Schade was the first recipient. Mr. Jensen is chairman of the Standards Committee of the Institute of Radio Engineers. In Europe this year, he was awarded the G. A. Hagemann Gold Medal by the Royal Technical College for his contributions to the field of engineering research.

Gretchen Ann Margaret, of the University of Wisconsin Psychology Department, has resigned to take a position in psychiatry with the College of Medicine of the University of Illinois. Professor Margaret went to Wisconsin in 1945 after teaching at Stanford University.

Bastiaan J. D. Meeuse, formerly acting head of the Biochemical Laboratory at Delft, Holland, has joined the staff of the Department of Botany at the University of Washington. Dr. Meeuse will teach plant physiology and plant biochemistry and will continue his research on the biochemistry of polysaccharides.

Douglas Geoffrey Northcott has succeeded **A. G. Walker** in the chair of mathematics in the University of Sheffield. In 1947 he took up a Princeton fellowship, and while in the U. S. he was elected to a research fellowship in St. John's College, Cambridge. Soon after his return to England in 1949 he was appointed a university assistant lecturer at Cambridge, becoming a full university lecturer in 1951 in the geometry school.

William F. O'Connor has been named chairman of the Chemistry Department at Fordham University. Dr. O'Connor went to Fordham in 1947 as an associate professor of chemistry and chairman of the research committee. In 1950 he was appointed director of the Fordham Research Foundation.

H. Neil Richardson, of Syracuse University, has been appointed fellow for 1952–53 in the School of Jerusalem. He will work in the school's archaeological programs at ancient Jericho and Dhiban in the Hashemite Kingdom of the Jordan.

Herschel Roman, professor of botany at the University of Washington, will spend a sabbatical year as a Guggenheim fellow working with Boris Ephrussi at the University of Paris on the genetics of yeast. Before returning to the U. S. in September 1953, Dr. Roman will visit yeast genetics laboratories in Denmark, Sweden, and England, and will also attend the International Genetics Congress in Bellagio, Italy.

Merritt P. Sarles has been appointed associate professor of biology at the Catholic University of America, where he will teach and direct graduate work in parasitology. Dr. Sarles was formerly parasitologist and toxicologist with the Entomological Division, U. S. Industrial Chemicals Co., of Baltimore, Md., and brings to his new position a wide range of experience attained in the Bureau of Animal Industry and Entomology, in the Department of Bacteriology and Parasitology of the University of Chicago, and in the De-

partment of Animal Pathology of the Rockefeller Institute for Medical Research at Princeton, N. J.

Roland B. Scott, head of the Howard University Department of Pediatrics, recently returned from a tour of European pediatric teaching centers in London, Newcastle-upon-Tyne, Birmingham, Manchester, Edinburgh, Stockholm, and Paris. While in London, Dr. Scott gave a guest lecture at the Great Ormond Street Hospital for Sick Children on "Management of Bronchial Asthma in Childhood."

Seton H. Thompson, chief of the Fish and Wildlife Service's Branch of Alaska Fisheries, has been appointed by President Truman as one of the two U. S. members of the International Fisheries Commission. Mr. Thompson succeeds **Milton C. James,** who retired Mar. 13 as assistant director of the Service (SCIENCE, **116,** 51 [1952]). Mr. Thompson has been associated with the Fish and Wildlife Service and its predecessor agency, the Bureau of Fisheries, since 1926.

Norman H. Topping, of the U. S. Public Health Service, has been appointed vice president of the University of Pennsylvania in charge of medical affairs, effective Nov. 1. Dr. Topping is associate director of the National Institutes of Health at Bethesda, Md. As medical vice president, Dr. Topping will be the principal administrative officer of the university's whole medical program—the School of Medicine, Graduate School of Medicine, School of Dentistry, School of Veterinary Medicine, School of Nursing Education, School of Auxiliary Medical Services, and the related hospitals and laboratories.

Frits W. Went, professor of plant physiology and head of the Earhart Plant Research Laboratory at the California Institute of Technology, has undertaken a lecture tour through western Europe. In London he will attend the International Horticultural Congress, where he will speak on the control of plant growth. He plans to visit all the major agricultural experimental stations in England, the Netherlands (his birthplace), Denmark, Sweden, Germany, Switzerland, and Belgium. He will confer with other scientists on construction of laboratories similar to Earhart, and will visit the only other similar installation, located in Liége.

Education

Armour Research Foundation of Illinois Institute of Technology has named François J. Olmer, of Celanese Corporation, research physical chemist. Dr. Olmer, a specialist in high polymer physics, came to this country in 1940, shortly after the Nazi invasion of Paris, as a research associate at the University of Missouri. Illinois Tech has promoted the following staff members: John G. Duba (civil engineering), Lewis P. Elbinger (electrical engineering), and Maurice D. Kilbridge (industrial engineering).

The following scientists have joined the Physics Department and Radiation Laboratory staffs of the **University of Pittsburgh:** Edward Gerjuoy, of New York University; Jan Yntema, of Princeton; and James McGruer and William Benesch. Dr. Benesch is currently in Liége, where he is working in the laboratories of the Astrophysical Institute, under Marcel Migeotte (SCIENCE, **116,** 270 [1952]).

Purdue University has added five members to the teaching and research staff of the Department of Biological Sciences: A. B. Burdick, of the University of Arkansas (genetics); Merwin Moskowitz, of Yale (medical bacteriology and immunochemistry); James M. McFadden, of St. Elizabeth's Hospital (medical pathology); Harold Garner (microbial genetics); and Seymour Benzer, of the Department of Physics, who has been on leave at the University of Paris (biophysics).

In a joint project of the **University of Texas** M. D. Anderson Hospital for Cancer Research, the Hogg Foundation for Mental Hygiene, and the Department of Psychology at the university in Austin, a medical psychology training research program will be started this year at the hospital in Houston. Staff members will include Beatrix Cobb and John I. Wheeler, Jr.

Grants and Fellowships

The **American Society for Metals** has given three cash prizes of $2000 each for the best teaching in the field of metallurgical engineering in 1951–52. The prizes, to be awarded during the National Metal Congress in Philadelphia, Oct. 20–24, will go to Arthur A. Burr, of Rensselaer Polytechnic Institute; Joseph W. Spretnak, of Ohio State; and Robert D. Stout, of Lehigh.

General Motors Corporation has established a graduate fellowship in electrochemistry at the University of Michigan, which will be offered for the first time in 1952–53. Applicants should write at once to Alfred L. Ferguson, Department of Chemistry, University of Michigan, Ann Arbor.

The **Hematology Research Foundation,** organized in 1943 to provide funds for research on leukemia, Hodgkin's, and other blood diseases, has awarded the Ruth Berger Reader Fellowship to Herbert M. Rubinstein, of Michael Reese Hospital, Chicago. Other grants were made to Robert M. Kark, University of Illinois; I. Davidsohn, Mt. Sinai Hospital; Allen H. Minor, Lenox Hill Hospital, New York; and Howard L. Alt, Northwestern University Medical School.

The **Lasdon Foundation** has made a grant of $20,000 to Alvin Coburn, director of the Rheumatic Fever Institute, Northwestern University Medical School, for further research in that field. The institute has headquarters in the Municipal Hospital for Contagious Diseases, Chicago, and draws its material from low-income areas.

The **Louis Livingston Seaman Fund,** of the New York Academy of Medicine, has $1900 available for

research in bacteriology and sanitary science in 1952. Applications from institutions or individuals should be addressed (before *Dec. 1*) to Wilson G. Smillie, 1300 York Ave., New York 21.

In the Laboratories

American Cyanamid Company, Calco Chemical Division, has appointed Ames B. Hettrick manager of the new Engineering and Development Department, which consolidates all engineering and process development functions that were previously part of the Production and Technical departments. Alden R. Loosli will become assistant to the general manager of the division on Jan. 1, and V. E. Wellman will become assistant manager of the Intermediate and Rubber Chemicals Department.

The **H. Fletcher Brown Laboratory** at the University of Delaware will be dedicated Oct. 18 in ceremonies that will include addresses on chemical reaction kinetics by Farrington Daniels, of the University of Wisconsin, and Richard Wilhelm, of Princeton. The addresses will be followed by discussions of research in progress in chemical engineering and chemistry and a tour of the laboratory. All interested scientists are invited to attend.

Chemstrand Corporation has appointed the following chemists to its staff at the Decatur (Ga.) Acrilan plant: Carlyle J. Stehman, William T. Dye, Jr., Arthur B. Beindorff, James W. Stoops, Howard A. Chamberlin, Garnett L. Wade, Jr., and Daniel L. Worth.

General Electric Research Laboratory is beginning a one-year study of long-distance weather migrations and cloud physics for the Office of Naval Research. Irving Langmuir will conduct the research in weather movements, devoting full time to the project. The laboratory study of cloud physics will be conducted by Vincent J. Schaefer and Raymond E. Falconer. The new project has no connection with Project Cirrus, joint weather research program of the Army Signal Corps and ONR.

The **Glenn L. Martin** Company has appointed Howard W. Merrill chief electromechanical engineer and has promoted Giles J. Strickroth, Sanford Hershfield, and Fred B. Haynes, in a reorganization of the Electronics Department. Charles A. Blaney, Jr., formerly production manager, has been made manager of Plant 2, where Martin is building the B-57A bomber for the USAF. George A. Huggins will succeed Mr. Blaney.

Directors of **E. R. Squibb & Sons** and of **Mathieson Chemical Corporation** have adopted a merger agreement that will be submitted to shareholders for approval at special meetings on Sept. 30. Under the terms of the agreement, Mathieson Chemical, which was founded in 1892, will be the surviving corporation. Thomas S. Nichols, Mathieson president, will be president and chairman of the board of the merged corporation. Squibb will be operated as a separate division and will retain the name and continue the policies and standards of the 94-year-old pharmaceutical house.

Meetings and Elections

A memorial meeting for Franz M. Groedel will be held by the **American College of Cardiology** at the New York Academy of Medicine Oct. 14 at 8:30 P.M. The program will consist of a symposium on critical evaluation of graphic registrations, a field in which Dr. Groedel, first president of the college, made fundamental contributions. J. E. Smith, CAA; John S. Graettinger, U. S. Naval School of Aviation Medicine; and Hubert Mann, Bruno Kisch, and Arthur Briskier will be among the speakers. Simon Dack will preside.

The **American Dental Association** (AAAS Section N associate) has named Leslie M. FitzGerald, of Dubuque, Iowa, president-elect. Otto Brandhorst, dean of Washington University School of Dentistry, was installed as president. Henry F. Westhoff, Fritz A. Pierson, and John F. O'Keefe were installed as vice presidents, and Harold Hillenbrand and H. B. Washburn were re-elected secretary and treasurer, respectively. The 1953 meeting will be held in Cleveland, Sept. 28–Oct. 1.

At the annual meeting of the **American Political Science Association** (affiliated with AAAS Section K) Pendleton Herring, president of the Social Science Research Council, became president, succeeding Luther Gulich. Ralph J. Bunche was named president-elect, and Charles Aikin, Charles McKinley, and E. E. Schattschneider were elected vice presidents. Walter H. Bennett, Hugh A. Bone, Robert A. Dahl, David Fellman, Victor Jones, Jack W. Peltason, Emmette S. Redford, and Clinton L. Rossiter were elected to the executive Council.

The Central States Section of the **Botanical Society of America** has elected John Winter, of the University of South Dakota, chairman, and Dwight M. Moore, of the University of Arkansas, vice chairman. Elzada U. Clover, of the University of Michigan, was elected to the Executive Committee.

The **Building Research Advisory Board** of the National Research Council–National Academy of Sciences will hold a conference on "Housing and Building in Hot-Humid and Hot-Dry Climates" Nov. 18–19 in Washington, D. C. Among the speakers will be Ralph Walker, Douglas H. K. Lee, Victor Olgyay, Albert Mayer, Aladar Olgyay, Robert H. Reed, Robert Deering, George M. Rapp, R. F. Dawson, J. Neils Thompson, W. R. Woolrich, G. E. Sutton, L. Thornburg, and T. H. Urdahl. Panel discussions will be held following each session. Registration forms may be obtained from the board, 2101 Constitution Ave., N.W., Washington 25, D. C.

Under the auspices of the **Committee on Lipoproteins and Atherosclerosis,** a technical symposium will

be held at the Knickerbocker Hotel, Chicago, Nov. 8, just preceding the annual meeting of the American Society for the Study of Arteriosclerosis. The committee was established in 1950 by the National Advisory Heart Council to plan and direct a cooperative study involving the determination of serum lipoprotein by the ultracentrifuge flotation technique. The symposium will not include a discussion of the results of the study, which has not yet been completed, but will deal with various technical problems. Those who wish to attend should make their own hotel reservations, but should notify J. Franklin Yeager, National Heart Institute, Bethesda 14, Md., from whom further information may be obtained. E. Cowles Andrus will serve as chairman of the meeting.

The **Society for Applied Spectroscopy** has elected E. J. Rosenbaum, of Sun Oil Co., president and Van Zandt Williams, of Perkin-Elmer Corporation, vice president. Charles Jedlicka, of Lucius Pitkin, Inc., and Charles H. North, of National Lead Co., were elected secretary and treasurer, respectively.

Miscellaneous

The **Atomic Energy Commission** Committee of Senior Reviewers has been increased from four to six members. New committee members are R. H. Crist, J. R. Richardson, Thomas B. Drew, and John P. Howe. Warren C. Johnson and J. M. B. Kellogg were reappointed, and W. F. Libby and R. L. Thornton resigned because of the press of other duties. Membership on the committee is for a five-year term.

The **Division of Chronic Disease and Tuberculosis** of the Bureau of State Services, USPHS, has established a program in the hygiene of aging. Cletus L. Krag, former research assistant, Division of Gerontology, Washington University School of Medicine, will direct the work, which is designed to demonstrate how state and local health departments can help meet the needs of our rapidly increasing population of persons over 65.

The **National Geographic Society** will support a comprehensive oceanographic expedition that will spend the next four years in undersea explorations around the globe. Leader of the expedition, which has the official backing of the French government and the French Academy of Sciences, will be Jacques-Yves Cousteau, coinventor of the Aqualung. The expedition ship is the *Calypso,* a converted American minesweeper. During the first two years the expedition will work in the Sargasso Sea, off Bermuda, at the mouth of the Amazon, along the coast of Patagonia, and in the Wedell Sea. The second two years will be spent off New Zealand, in the Ross Sea, along the Great Barrier Reef, in the Arabian Sea, and along the seacoast of Africa.

New journals received: *Japanese Journal of Ichthyology* (Japanese, with English abstracts). Bimonthly; Vol. I, No. 1, August 20, 1950. $4.50. Japanese Society of Ichthyologists. Publishing office: Nippon Gyogaku Shinko Kai, Tsukiji, 5-chōme, 1-banchi, Kyobashi, Tokyo. . . . *Japanese Journal of Pharmacology.* Official publication of the Japanese Pharmacological Society. Replaces *Japanese Journal of Medical Sciences,* Part IV, *Pharmacology.* Semiannual; Vol. I, No. 1, Sept. 1951. Editorial Office: c-o Department of Pharmacology, Faculty of Medicine, Kyoto University, Kyoto. . . . *The Keio Journal of Medicine.* Quarterly; Vol. 1, No. 1, Jan. 1952. $4.00, including postage; School of Medicine, Keio University, Shinjuku-ku, Tokyo. . . . *The Kumamoto Medical Journal.* Quarterly; Vol. 4, No. 2, Dec. 30, 1951. Kumamoto University College of Medicine, Kumamoto, Japan. . . . *Kyushu Memoirs of Medical Sciences* (English and other languages). Vol. 1, No. 1, June 1950. Kyushu University Faculty of Medicine, Fukuoka, Japan. . . . *Museum Pictorial.* Four or more issues per year, each restricted to a single title; No. 1, Feb. 1, 1951. 50¢ each, plus 6¢ postage. Denver Museum of Natural History, City Park, Denver, Colo. . . . *Revista Chilena de Entomología* (uses language of its writers). Facultad de Filosofía y Educación (Universidad de Chile) y de la Sociedad Chilena de Entomología. Vol. 1, 1951. $3.50 U.S. . . . *Scientific Papers of the College of General Education, University of Tokyo.* Semiannual; Vol. 1, No. 1, Oct. 1951. . . . *Tlatoani* (Spanish). *Boletin de la Sociedad de Alumnos de la Escuela Nacional de Antropología e Historia, México, D. F.* Bimonthly; Vol. I, No. 2, March–April 1952. $1.50 U.S. . . . *Transactions of the American College of Cardiology.* Vol. I, 1951. Publication Committee: 140 W. 57th St., New York 19.

The **Ordnance Development Division** of the National Bureau of Standards has been reorganized into Divisions 13, 16, and 17, which will deal with Ordnance Development Programs A, B, and C. New chiefs of the divisions are M. G. Domsitz, Jacob Rabinow, and Harold Goldberg. Wilbur S. Hinman, Jr., former chief of the division, has been appointed to the newly established position of associate director.

The government of **Poland** has awarded prizes in medicine to the following: Tadeusz Urbanski, Jakub Wegierko, Damian Cembala, and Stefan Slopek. Other science prizes went to Jan Stach (paleontology); Tadeusz Baranowski (chemistry); Stanislaw Maziarski (histology); Ignacy Reifer (botany); Wladyslaw Orlicz (mathematics); Stefan Piotrowski (astrophysics). A joint prize was given to a team of four investigators of cosmic rays headed by Marian Miesowicz. In the technical sciences the following were honored: Aleksander Rylke, Ignacy Malecki, Jaroslaw Naloszkiewicz, Wladyslaw Wyrzykowski, Szymon Jachimowicz, and Tadeusz Soltyk.

The **Torry Research Station,** Aberdeen, Scotland, will be the recipient of a trawler, which will function also as a laboratory designed for the study of fish preservation and spoilage. The order for the laboratory-ship has been placed by the United Kingdom's Department of Scientific and Industrial Development as part of its program of research on Great Britain's fishing industry.

Technical Papers

Revascularization of the Heart by a Pedicle Skin Flap

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This is a preliminary report on a series of experiments carried out in dogs for the purpose of developing a new blood supply to the myocardium by means of a skin flap.

One of the authors (R. E. M.) observed several years ago an unusual property of pedicle flaps during an attempted transplantation of a flap from one individual to another. The flap was a delayed tubed flap, transferred between individuals who were close blood relatives and whose blood types were identical. On the fourth day following transplantation the donor developed signs of shock and anemia. It became apparent that a large volume of the donor's blood was being transferred to the circulation of the recipient through the tube, and, despite multiple transfusions in the opposite direction, the donor developed a severe anemia and the recipient a severe polycythemia which necessitated division of the tube. The volume of blood which this tube was capable of transporting suggested that a flap of skin and subcutaneous tissue might prove successful as a vehicle to carry a new blood supply to the heart. To our knowledge a skin flap has never been used for this purpose.

Accordingly, we embarked on a series of experiments with the purpose of finding out whether the operation was possible and, if so, how high a mortality it would entail. Second, we hoped to demonstrate whether anastomoses occur between the blood vessels in the flap and those in the heart. And third, if anastomoses could be demonstrated, we wished to discover whether a sufficient volume of blood could be carried by the flap to protect the heart against occlusion of a coronary artery.

Twenty-five dogs have been studied to date, in trying different techniques of constructing and attaching the flap and using a number of methods to evaluate its effect. The animals averaged 18 kg in weight. The type of flap we have found most useful is a single pedicle flap, raised and implanted in one stage. The operation consisted of elevating a thoracoabdominal flap, based over the fifth or sixth ribs near the apex of the heart. A segment of the sixth rib was removed to provide room for passage of the flap through the chest wall, and the proximal portion of the flap was tubed so that the tubed part of the flap extended the entire distance between the chest wall and the heart. The remaining open portion of the flap was then passed through an incision in the pericardium, sutured directly to the myocardium over the apex, and the chest was closed firmly about the tube. The epithelium of the tube was not disturbed. The reason for tubing that portion of the flap between the chest wall and the heart and not removing the secretory elements of the epithelium was to produce as critical an experiment as possible by excluding all sources of blood supply other than that which passed directly through the pedicle. The flaps averaged 16 cm in length by 9 cm in width at the base, tapering toward the distal end and varying somewhat in size with the size of the animal. This allowed us to cover approximately one third the area of each ventricle with the open portion of the flap, so that areas of myocardium supplied by all the coronary vessels had access to the vessels of the flap.

No deaths occurred directly as a result of attaching the flap. Two animals died during the operative procedure, but both deaths were the result of anesthetic accidents. Postoperatively the dogs appeared healthy and normal for periods up to 6 months following the operation.

The flap produced no apparent effect on cardiac function. No constriction of the heart occurred, and although the heart was rotated in a few cases as a result of a somewhat short pedicle, no demonstrable interference with its mechanical function resulted. Little inflammatory reaction occurred in the portion of the pericardial cavity not covered by the flap, for the pericardium rapidly became attached to the edges of the flap, preventing escape of skin secretions into the free pericardial cavity.

No dog developed either a pneumothorax or an empyema. When the animals were sacrificed it was found that the tube had become completely walled off from the free chest cavity by adherent lung, and that sinus tracts had developed along the tube from the pericardial cavity to the surface through which the secretions of the tube drained.

The changes observed in the electrocardiogram followed a definite pattern. Immediately following the operation, depression in voltage and changes in the QRS complexes appeared, which resulted partly from positional changes of the heart. These soon disappeared, but by the fourth or fifth week progressive changes appeared in the T waves, with elevation of the ST segments which simulated the changes seen in pericarditis.

To demonstrate the presence of anastomoses between the vessels of the flap and those of the myocardium, several methods were used.

Employing a specimen removed from one of the early animals a cannula was inserted in the descending ramus of the left coronary artery and 35% diodrast and gentian violet were injected under a pressure of 70 mm Hg. The colored dye was seen to drip from the cut end of the pedicle and the radiopaque

medium was demonstrated in the vessels of the tube by x-ray.

A second method was based on the premise that if good anastomoses were present between the vessels of the flap and those of the heart, they might carry sufficient blood to support the tube with its pedicle divided. Accordingly, in an animal with a flap implanted for one month, the base of the pedicle was completely transected so that its only source of blood was through the surface of the flap attached to the heart. Arterial blood spurted from the distal cut surface of the tube, and one week later, when the animal was sacrificed, the tube appeared viable, with healthy granulations on its cut surface.

In another animal we observed direct evidences of anastomoses during a secondary operation, 1 month after a flap had been applied. The descending ramus of the left coronary artery was dissected out, ligated, and divided distal to the ligature. The distal cut end of the vessel spurted arterial blood which must have come either through the pedicle or from one of the other coronary arteries with the flap acting as a bridge.

In order to demonstrate the anastomoses visually, a method was developed by which radiopaque material could be injected through the vessels of the tube. The injection medium used was a 20% aqueous suspension of bismuth oxychloride, which has a particle size too large to pass through the capillaries, and will not pass through arterioles smaller than 35 or 40 μ in diameter. The technique consisted of isolating the coronary vessels by ligating the aorta immediately distal to their origin. The segment of aorta whose branches supplied the left chest wall and the vessels of the flap was then isolated by ligating the descending thoracic aorta above the diaphragm, and the injection was carried out through this segment under a pressure of 220 mm Hg. The injection mass flowed through the vessels of the chest wall into the vessels of the tube and then passed through numerous anastomoses to fill the coronary vessels. None of the injection medium was found in the veins because the bismuth could not pass the capillary barrier. Since the injection medium found in the coronary vessels was derived from the flap, the anastomoses were demonstrated to be at least arteriolar in caliber (Fig. 1).

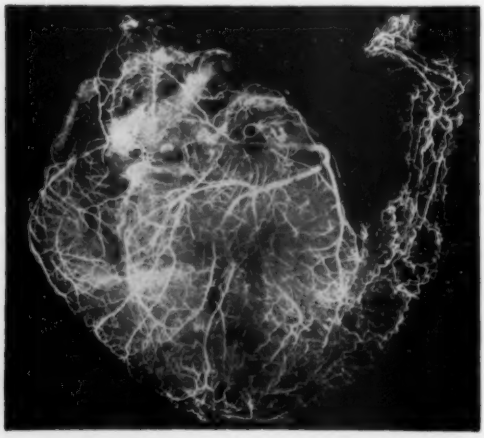

FIG. 1. X-ray of a heart to which a flap had been attached for 1 month, injected by method described in text. All the bismuth seen in the coronary arteries passed through the pedicle.

The experiments carried out so far have demonstrated that a skin flap may be attached to the heart without harmful sequelae, and that macroscopic anastomoses occur between the vessels of the flap and the coronary arterial circulation of the heart. Although three animals protected by a flap have had the descending ramus of the left coronary artery ligated without mortality, the series is too small to be significant, and further studies are under way to establish whether the flap carries a sufficient volume of blood to protect the heart against coronary occlusion.

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Abnormal Growth and Fructification of the Cultivated Mushroom

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Since the seventeenth century it has been customary to induce the development of the mushroom fruiting bodies, or sporophores, by covering the surface of mycelium-impregnated compost with a layer of loam about 1 in. deep. The function of this layer of soil in initiating fructification of the cultivated mushroom *Agaricus campestris* L. has never been proved experimentally. A study of abnormal growth may provide the entering wedge for understanding this function.

The stems of mushrooms growing on beds sometimes elongate abnormally, and at the same time, the growth of the caps is retarded. Lambert (*1*) claims to have demonstrated experimentally that this abnormal growth is due to the injurious effects of carbon dioxide released during respiration of sporophores. An evaluation of his results reveals, however, that there is slight, if any, elongation of the stem when the CO_2 introduced under the bell jars is derived from commercial cylinders; whereas severe abnormal growth occurs if the gases accumulate from respiration. It appears that in the gases accumulating naturally there may be another volatile substance which is responsible for this abnormal growth.

In this paper, an attempt is made to demonstrate that an elongation of the stem and retardation of the cap may occur even in the complete absence of carbon dioxide. The device employed to investigate this point (*2*) was a bell jar with two openings, one in the top and the other in the side at the bottom (Fig. 1, No. 3). When this kind of bell jar was placed over mushrooms

[1] The writer is indebted to J. R. Stauffer, University of Wisconsin, for facilities and aid.

FIG. 1. Effect of volatile substances on growth of sporophores when covered with bell jars which have openings at top only, Nos. 1 and 2; at top and side, No. 3. Pots Nos. 4 and 5 are controls. (Jars were fastened to pots with rubber bands cut from inner tubes.)

growing in 2-gal earthenware pots, it was found that there was no accumulation of CO_2 in the bell jar as a result of respiration, whereas in bell jars where there was an opening only in the top (Fig. 1, Nos. 1 and 2), there was a considerable accumulation of CO_2. The openings in the jars were left *open* throughout the experiment, except momentarily when drawing samples for analysis. The atmosphere in the bell jars was analyzed for CO_2 with an Orsat apparatus (accuracy $\pm 0.1\%$). To withdraw 100-ml samples, a glass tube was inserted through a rubber stopper placed in the opening at the top of the bell jar and lowered to about an inch above the soil. The side opening in the bell jar with two outlets was closed with a rubber stopper during analysis. Prior to fastening the jars onto the pots, the surface soil was sprinkled with 50 ml water in order to enhance the release of CO_2 microbiologically. The CO_2 used was the gas naturally evolved from respiration rather than that obtained from commercial cylinders and injected under the jars, as in Lambert's experiments. Mushrooms were growing in the pin-size stage on pots selected for the experiments.

It is evident from Fig. 1 that abnormal growth was very severe at high concentrations of CO_2; however, the effect on growth was much more marked at 0.8–1.2% CO_2 in these experiments than in Lambert's, where the CO_2 was delivered from commercial cylinders. It may be observed from Pot No. 3, Fig. 1, and from Table 1 that mushrooms growing in the bell jar with two outlets have distinctly elongated stems and retarded caps, even though no CO_2 was detected in the jar. That CO_2 was actively evolving from the soil (even when no sporophores were growing) could be proved by closing the outlets of the bell jars with a rubber stopper. Under these conditions the CO_2 in the jars increased to 18% in 5 days. It may be inferred, therefore, that the CO_2 diffused out completely from the bell jar with two outlets, but only partially from the bell jars with one outlet; the amount of CO_2 accumulating in the latter depended on the diameter of the opening.

TABLE 1

ACCUMULATION OF CO_2 IN BELL JARS WHEN FASTENED ON POTS SHOWN IN FIG. 1. EXPERIMENT REPEATED FOUR TIMES

No.	Diam of opening at top of jar (cm)	No. of days (percentage CO_2)			
		1	3	4	6
1	5.5	0.8	1.1	1.2	1.2
2	3.0	1.6	2.8	3.4	4.0
3	3.0*	0	0	0	0

* Diam of opening at side, 1.5 cm.

From the fact that the mushrooms grew abnormally in the absence of CO_2, it may be hypothesized that another volatile substance affected the growth. Carbon dioxide is a small molecule, with a small relative density or molar weight, with a very low boiling point, and a gas at ordinary temperature. Accordingly, the rate of diffusion of CO_2, considering Graham's law of diffusion, would be expected to be rapid, especially through the "chimney" effect of the bell jar with a lower and upper opening. Reasoning similarly for the hypothetical volatile substance, it may be considered to have a large molecular weight, with a high boiling point and low volatility, so that its rate of diffusion would be much slower than that of CO_2. Since the latter diffused slowly, a sufficient concentration was present in the bell jar, especially surrounding the sporophores, to affect the nature of their growth. Thus, by means of a bell jar with two outlets, it was possible to arrange for a differential rate of diffusion.

A hypothesis may be proposed that some volatile substance emitted from the mycelium in the compost and in the casing soil accumulates when there is insufficient ventilation or when the mushrooms are growing thickly on the beds. Mader (*3*) also found that "wherever mushrooms are grown, substances of a volatile nature accumulate and become detrimental to their growth and fructification," although the writer is at a loss to understand his experimental procedure. A volatile substance or substances emitted from the mycelium have been detected by absorbing solutions of guaiacum resin or benzidine in pure filter paper, and then suspending the papers in bell jars over a pot of mycelium-impregnated compost (*4*). The papers become colored blue and brown, respectively, indicating that the substance volatilizing is of an oxidizing nature. Adequate controls were carried out simultaneously by suspending papers containing the reagents in jars over pots of water. Similar color changes were produced in agar slants as "halos" advancing ahead of the growing mycelium, with these reagents as well as with many others.

This volatile substance may also give some indication of a defensive mechanism (*4*). For example, when lead acetate test papers, darkened (showing evolution of a sulfide) by suspending them over cultures of *Pseudobalsamia microspora* (a pathogen of the mushroom mycelium), were suspended over mushroom cultures by the same procedure described above, the dark-

ened papers were decolorized. It was suggested this substance is in the nature of a quinone.

The significance of this volatile substance may be, then, that it acts like an "antibiotic" or defensive mechanism for mycelial growth; that it inhibits fructification unless it is modified in the casing soil; and that it affects normal growth when allowed to accumulate. It is of interest to note that pathogens which do not attack the mycelium in the compost, do so in the casing soil—that is, in the medium where the antibiotic value of this volatile substance is at the lowest ebb. The intensity or high potential of the substance diffusing from the mycelium was shown by embedding oxidation-reduction indicators in agar slants (*5*). It appears that the oxidizing intensity of this substance is so great that it prevents the thickening of the hyphae from which sporophores develop. The necessity for adjusting the soil at a relatively high pH for best fructification tends to show that the soil must be a medium suitable for rapid oxidation-reduction reactions. A movement of air or oxygen-ventilation is, of course, required for such reactions. Accordingly, at least one of the functions of the casing soil is to provide an alkaline-oxygenated medium for the destruction of this volatile substance. A fuller presentation will be published elsewhere.

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The Medical Examination of Hiroshima Patients with Radiation Cataracts[1]

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Radiation cataracts, the first late manifestation of exposure to atomic bomb radiation reported in man, have been described by Cogan, Martin, and Kimura (*1*), and Cogan, Martin, Kimura, and Ikui (*2*). Kimura (*3*) reported 98 Hiroshima patients with radiation cataracts. Eighty-five of the 98 were among 922 survivors 1000 m (1094 yards) or less from the hypocenter,[3] an incidence of 9.8%.

This group of 98 patients with radiation cataracts is a select group because all were unquestionably exposed and all show unmistakable delayed response to radiation injury. Seventy-eight of them have been examined by the medical department of the Atomic Bomb Casualty Commission Clinic in Hiroshima in an effort to discover if other late manifestations of radiation injury exist. The examinations were performed approximately five years after exposure.

The group comprised 45 men and 33 women between the ages of 12 and 69 years, and they had been from 150 to 1240 m from the hypocenter; 64 were between 700 and 1099 m (710–1202 yards). Detailed radiation and medical histories were obtained, and physical examinations were performed. Roentgenograms of the chest and blood, and urine and stool specimens were examined. Thirty-four patients were proctoscoped, and sternal marrow specimens were obtained from 27 patients. Additional diagnostic studies were performed as indicated.

Symptoms presumably produced by acute radiation were vomiting, fever, diarrhea, oropharyngeal lesions, bleeding gums, purpura, epilation, amenorrhea, and abnormal periods after amenorrhea. At least 50% of the patients experienced fever, purpura, epilation, amenorrhea, and vomiting on the day of exposure, suggesting that at least half of them received severe irradiation.

Forty-six of the 78 patients received mechanical injuries described as minor lacerations and penetrating wounds from flying glass and other small objects. Several patients were bruised by falling beams and roofs, but the only major injury was a depressed skull fracture. As far as could be determined, all injuries resulted from indirect blast effects. Small thermal flash burns occurred in 15 patients. Five of the burned patients were free from flash burn scars, suggesting partial shielding from thermal injury. One scar resembled a keloid.

Seventy-seven of the 78 patients experienced scalp epilation. This observation suggests that a cataractogenic dose will produce some degree of scalp epilation in the majority of patients.

Two males and one female above 39 years of age had diastolic blood pressures of 100 mm Hg or higher. The remaining individuals had blood pressure recordings within the usual range. Thirty-six patients had scars from burns and/or wounds sustained at the time of the explosion. The majority were minor and showed only small amounts of scar tissue. Radiation cataract was the only physical finding attributed to the late effects of the atomic bomb.

At the time of the study the hematological findings did not disclose any blood dyscrasias. Two patients with radiation cataracts have developed acute leukemia, one of them subsequent to her examination in this study and one child not included in this report. The aspiration sternal marrow specimens obtained on 27 patients were compatible with the peripheral hematological findings.

Chest films, stool and urine examinations, and serological tests for syphilis revealed no abnormalities that could be attributed to the atomic bomb. The histories did not reveal any information which suggested late effects of the atomic bomb other than visual complaints.

The shielding factor was not studied. The greatest

[1] Sponsored by the Atomic Bomb Casualty Commission, National Research Council, with funds supplied by the U. S. Atomic Energy Commission.

[2] Medical Department ABCC (1949–51); at present AEC postdoctoral research fellow.

[3] Point on the ground directly below the explosion.

number of patients with cataract formation in this series was 700–1000 m from the hypocenter. No cataracts have been found in the survivors in this report that were in the Fukuya Department Store, a reinforced concrete building 800 m from the hypocenter, where shielding was afforded.

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Histochemical Demonstration of Protein-bound Sulfhydryl Groups[1]

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Protein-bound or fixed sulfhydryl groups are essential for the activity of many enzymes, serve as linkages between proteins and some prosthetic groups, are involved in the contractile phenomena of muscle, and are important in the coagulation of blood, in cell permeability, and in hormone synthesis and activity (*1*). Methods for the detection as well as estimation of sulfhydryl groups of proteins are based on reactions with either oxidizing, reducing, alkylating, or mercaptide-forming agents. Some of these methods are not colorimetric, and most of them lack specificity because functional groups other than sulfhydryl are quite reactive toward these agents (*1*). However, modifications of some colorimetric techniques have been used histochemically to demonstrate sulfhydryls in tissue sections. For this purpose ferricyanide (*2*) and nitroprusside (*3, 4*) have been widely used, although no oxidizing agent other than cystine can be called specific for the oxidation of sulfhydryl groups in proteins (*1*). A method based on a new mercaptide-forming agent, 1-(4-chloromercuriphenylazo)-naphthol-2 (*5*), gives weak color reactions in tissue sections.

In order to improve the sensitivity of sulfhydryl histochemistry by increasing the color value of the final compound and by increasing the specificity of the reaction for sulfhydryls, a reagent was developed which contained a disulfide linkage, the specific oxidative group, and a naphthol moiety for coupling to form an azo dye. As shown in Fig. 1, the reagent,[3]

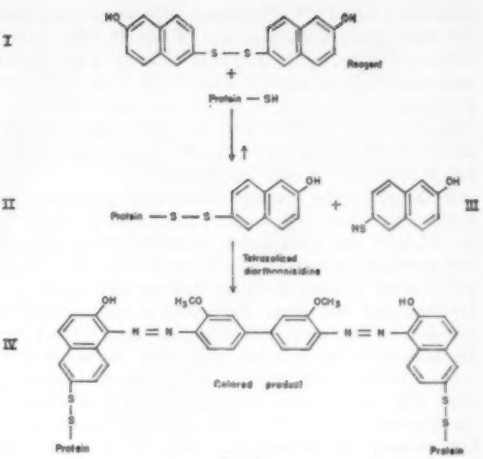

FIG. 1.

2,2′-dihydroxy-6,6′-dinaphthyl disulfide (I), when used in excess at pH 8.5, reacts with active sulfhydryl groups of fixed tissue proteins to form a colorless substance (II), which can be converted into an intensely colored azo dye (IV) by coupling with tetrazotized diorthoanisidine. The colorless oxidation product (II) was insoluble in both water and ether-alcohol, so that the excess of reagent (I) as well as the reduced reaction by-product (III) could be washed out of the tissues with organic solvents. Subsequent treatment of the tissues with tetrazotized diorthoanisidine resulted in the rapid development of a red color (monocoupling) or a blue color (dicoupling) at the sites of protein sulfhydryl groups (IV). Monocoupling (red or pink) was taken to indicate sparse, widely separated sulfhydryl groups, whereas dicoupling (blue) indicated a greater concentration of sulfhydryl groups.

The reagent (I) was prepared from sodium 2-hydroxy-6-naphthalene sulfonate. The hydroxy group was protected by conversion to the carbethoxy derivative, and the sulfonate group was converted to sulfonyl chloride with PCl_5 (*6, 7*). Reduction to a sulfhydryl group was accomplished with zinc dust and hydrochloric acid in alcohol, a method used for other naphthalene derivatives (*8*). Oxidation with ferric chloride gave the disulfide, and the carbethoxy group was hydrolyzed with hot alkali.

The required sodium-2-carbethoxy-6-naphthalene sulfonate (*6, 7*) was prepared by the slow addition of 84 ml ethyl chlorocarbonate to a vigorously stirred solution of 197 g sodium 2-hydroxy-6-naphthalene sulfonate (Eastman technical grade) and 32 g sodium hydroxide in 800 ml water. The stirring was continued for an additional hour, after which the mixture was cooled to complete the precipitation of the carbethoxy derivative. It was collected with the aid of suction and dried by warming on the steam bath. The crude product (177 g) was ground with an equal weight of phosphorus pentachloride and was heated on the steam

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[2] Acknowledgment for technical assistance is due Edith Herman and Ralph Gofstein.

[3] This reagent (DDD) is now available from the Schwartz Laboratories, Inc., New York City.

bath for 1 hr (*6, 7*). The fused melt was poured into 2.5 liters cracked ice and stirred for 20 min. *2-Carbethoxy-6-naphthalene sulfonyl chloride* was filtered with suction, immediately crystallized from 1 liter of hot glacial acetic acid, collected, and used in the next step. In order to determine the yield, one run was dried for 48 hr *in vacuo* at 40° C, mp 116°–118°, 103 g (41% of the starting material).

2-Carbethoxy-6-naphthyl thiol was prepared by heating zinc dust (100 g) and 95% alcohol (400 ml) to 30°, and the undried acid chloride (about 103 g) was gradually added. Concentrated HCl (200 ml) was added drop by drop to the stirred mixture. After the reaction had subsided, the mixture was gradually warmed on the steam bath and then heated for 1 hr. By this time the solution was clear yellow, and a sample diluted with water was completely soluble in base. The solution was rapidly filtered with suction, and the zinc dust on the filter was washed once with hot alcohol. The filtrate was used in the next step below. In one experiment the filtrate was poured into 2 liters of cold 10% HCl, and the pale-yellow product which precipitated was collected and crystallized from dilute alcohol, mp 87°, yield 72 g (90%).

2-Carbethoxy-2′-hydroxy-6,6′-dinaphthyl disulfide was prepared from the sulfhydryl compound (72 g) dissolved in 600 ml alcohol or from the hot alcoholic filtrate (obtained above without isolation of carbethoxynaphthyl thiol) by addition of 300 ml of a saturated aqueous solution of ferric chloride at 50° C. An excess of ferric chloride was assured by persistence of its yellow color. Cold water (600 ml) was added, the mixture was cooled, and the clay-colored disulfide was collected and washed with water. It crystallized from hot acetic acid or dioxane-methanol in fine white crystals, mp 198°–200° (uncorr). The compound proved to be the monocarbethoxy derivative by analysis. This was confirmed by demonstrating coupling with tetrazotized diorthoanisidine at pH 7.2.

Anal: Calcd for $C_{28}H_{18}O_4S_2$: C, 65.38; H, 4.26. Found: C, 65.68; H, 4.28.

2,2′-Dihydroxy-6,6′-dinaphthyl disulfide (*I*) was obtained by heating the crude undried disulfide suspended in 600 ml water and 54 g potassium hydroxide on a steam bath for 2 hr. The hot solution was filtered, cooled, and acidified with 150 ml concentrated HCl in a 4-liter beaker. The clay-colored product was collected, dissolved in hot acetic acid, treated with active charcoal, and crystallized from dilute acetic acid in pale-tan, fine crystals, mp 190°–205° (uncorr); 40.5 g (70% based on the acid chloride). Crude material could be purified by solution in a small amount of acetone, addition of a large volume of toluene and concentration by boiling to one third the volume. The hot toluene solution was filtered rapidly from tarry residue and crystallization took place upon cooling. After recrystallization from hot glacial acetic acid it melted at 220°–223° (uncorr).

Anal: Calcd for $C_{26}H_{14}O_4S_2$: C, 68.54, H, 4.03. Found: C, 68.34; H, 4.26.

For the histochemical detection of protein-bound sulfhydryl groups, tissues taken from rats killed by a blow on the head were fixed for 24 hr in a solution containing 1 g trichloracetic acid dissolved in 100 ml 80% ethyl alcohol. The acid prevented air oxidation of sulfhydryl groups. These tissues were dehydrated, embedded in paraffin in the usual manner, and sectioned at 10 μ. Tissue sections, mounted on slides with a minimal amount of albumin, adhered to the slides during staining procedures better than when albumin was omitted. This procedure was feasible since smears of albumin stained for sulfhydryl did not develop a sufficient amount of color to be detected. Moreover, there was no difference in the degree or localization of staining for sulfhydryl in a series of sections of tissues mounted with and without albumin. After deparaffinization, the mounted sections were passed through a series of alcohols (absolute, 95%, 70%, 50%) to distilled water. They were stained by the following procedures for demonstrating sulfhydryl groups.

1) Incubate up to 9 slides in Coplin jar for 1 hr at 50° C in a solution prepared by mixing 35 ml 0.1 *M* Michaelis barbital buffer, pH 8.5, and 15 ml absolute ethyl alcohol containing 25 mg 2,2′-dihydroxy-6,6′-dinaphthyl disulfide (I). The reagent is almost completely soluble in the above alcohol-buffer mixture.

2) Cool for 10 min at room temperature.

3) Rinse briefly in distilled water.

4) Wash for 10 min in 2 changes of distilled water acidified to pH 4 to 4.5 with acetic acid. This step is necessary to convert the sodium salt of the reagent (I) or of the reaction by-product (III) to free naphthol for extraction with organic solvents.

5) Extract excess reagent (I) and reaction by-product (III) by passage through a graded series of alcohols and wash in absolute ether for 5 min.

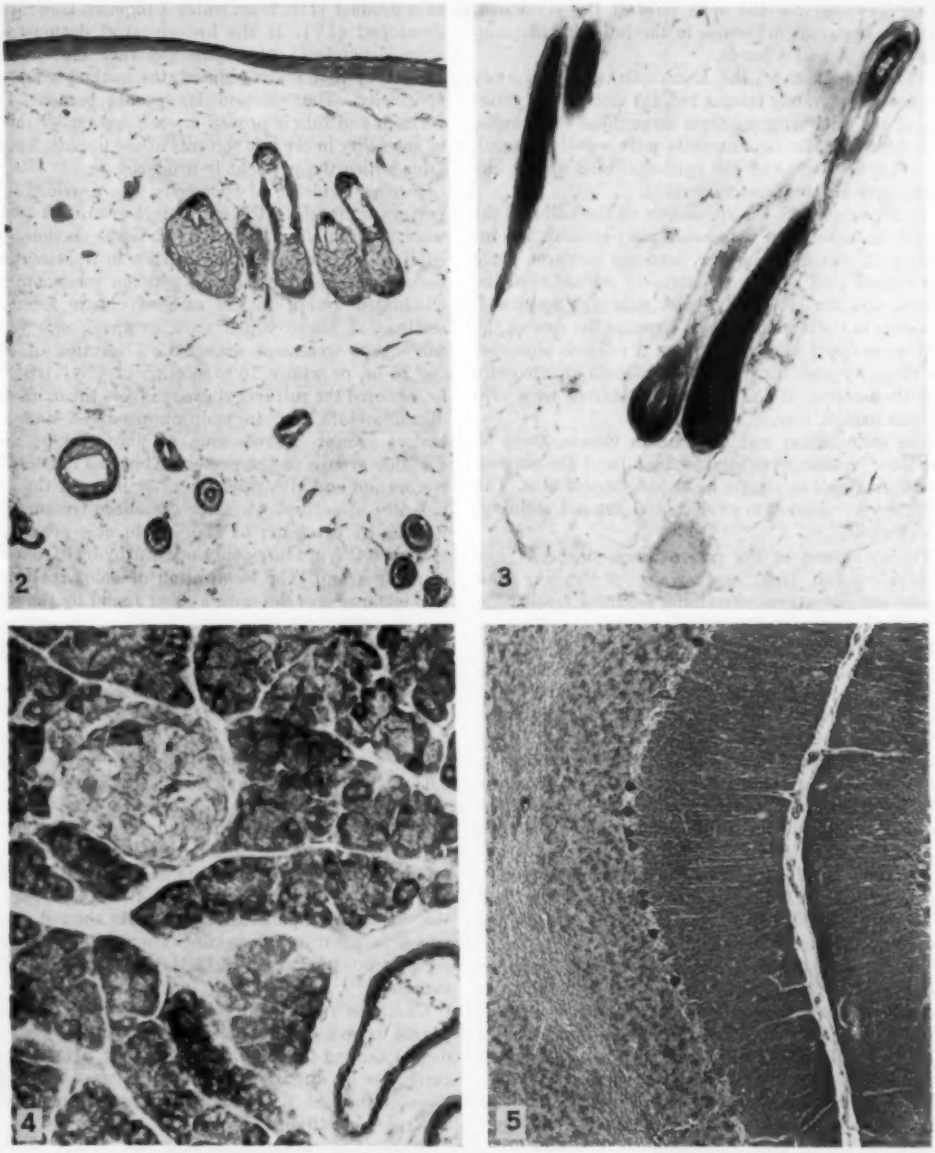
6) Rehydrate and rinse in distilled water.

7) Stain for 2 min at room temperature in the following freshly prepared mixture: 50 mg tetrazotized diorthoanisidine[8] in 50 ml 0.1 *M* Sorenson phosphate buffer, pH 7.4.

8) Wash in running tap water.

9) Mount cover glass with glycerogel, or dehydrate with acetone and mount cover glass with clarite.

Sulfhydryl groups were widespread in distribution in rat tissues. In sections of skin, the epithelial cells of the Malpighian layer were stained a moderately intense red (Fig. 2), whereas those of the stratum corneum were less intensely colored. The epithelial cells of the root sheaths of the hairs were also stained red, as were those of the bulb. The hair papilla, however, was unstained. The cells of the hair cortex stained a moderately intense red in the proximal parts of the hair, a deep blue in the region of horny transformation, and a reddish blue in the intermediate regions (Fig. 3). Distal to this region, the hair cortex was unstained, although the medulla was weakly stained. Connective tissue fibers of the dermis were unstained, but some of the cells of connective tissue were stained light red, as was the cytoplasm of fat cells. The epithelium of sebaceous glands (Fig. 2) and fibers of the arrectores pilorum muscles were stained red.



Figs. 2–5. Ten-micron sections of paraffin-embedded tissues of rats stained for sulfhydryl. 2: The cells of the stratum corneum and stratum Malpighii of the epidermis, the root sheaths of the hairs, and the epithelium of the sebaceous glands are stained red. The cortices of the hairs are unstained. Approx. ×100. 3: Adjacent deeper part of dermis to that in Fig. 2. The cortices of the hairs in the region of horny transformation are stained blue, whereas the root sheaths and the bulbs are stained red. Approx. ×100. 4: The acinar cells of the pancreas are stained reddish blue, and perinuclear and basal localization of staining is common. The cells of the islets of Langerhans are stained light pink. The elastica interna (nonsulfhydryl) and smooth muscle of an artery (lower right-hand corner of the photograph) are stained blue and red, respectively. Approx. ×300. 5: The Purkinje cells of the cerebellum are stained reddish blue, and the fibers of the molecular layer and the cells of the granular layer are stained red. The fibers of the white matter in medullary centers are virtually unstained. Approx. ×100.

In the deepest part of the dermis, the axis cylinders of nerve fibers were stained a light red, whereas the myelin sheaths were weakly stained or were unstained. Striated muscle was stained reddish blue, the staining

being localized for the most part in the myofibrils, with no apparent difference in the intensity of staining in the A and I bands.

The cytoplasm of the liver cells was uniformly stained a moderately intense red, the intensity of staining of the cells being uniform throughout the lobules. The nuclei of the hepatic cells were weakly stained. The Kupffer cells and the epithelial cells of the bile ducts were also moderately stained.

In the duodenum, the epithelium of the villi and the crypts of Lieberkühn were moderately stained. The intensity of staining, however, was not uniform, since the Paneth cells were more intensely stained than the others, and the mucus of goblet cells was unstained. The cells in the lamina propria forming the core of the villi were reactive, some staining a reddish blue, but the majority pink. The cells of the smooth muscle coats and the neurons of the myenteric plexuses were also stained reddish blue.

The endothelium and the smooth muscle fibers of the blood vessels were stained pink, and the elastica interna, as well as elastic fibers, an intense blue. The erythrocytes seemed to exhibit a slight red staining, if any at all.

The cytoplasm of the pancreatic acinar cells was stained reddish blue, and strong perinuclear and basilar concentrations of staining occurred frequently. The nuclei were virtually unstained (Fig. 4). The epithelial cells of the ducts and of the islets of Langerhans were stained pink. Some of the cells of the islets appeared to be slightly more deeply stained than others, but it should be emphasized that the islet cells, by virtue of their weak staining in comparison to the pancreatic acinar cells and the cells of other tissues, contained only a small amount of alcohol-insoluble protein-bound sulfhydryl (Fig. 4). A method for staining alcohol-soluble disulfide-containing substances will be published later.

The cells forming the cortical and medullary substance of thymic lobules were stained a diffuse and light pink. Hassell's corpuscles, however, were stained a moderately intense blue.

The fibers of the molecular layer of the cerebellar cortex were stained a moderately intense red (Fig. 5). The cells of the granular layer were similarly stained, but the fibers of this layer were much less intensely stained. The Purkinje cells between these two layers were stained most intensely red of all cerebellar elements, and the color was confined mainly to the cytoplasm. Fibers of the medullary centers were very lightly stained or were unstained.

Although derivatives of naphthol have proved useful in developing a variety of histochemical methods (*9–13*), success of the present method is dependent upon the specificity of the reaction of the disulfide group with sulfhydryl groups at alkaline pH (*1, 14–16*). The reaction is reversible and readily influenced by mass action. Furthermore, the reaction is not merely oxidation and reduction with transfer of electrons, but the chromogenic moiety (naphthol) is transferred to the protein and becomes part of the oxidation product (II), from which a pigment is eventually developed (IV). If the histochemical demonstration were dependent only upon the fact that III was formed or that I was reduced, the method would lack specificity. The reaction is specific because II is formed, and this is proved in each section by the loss of solubility in organic solvents of the naphthol moiety from which the pigment is produced.

Further evidence of specificity was provided in experiments in which the sulfhydryl groups of protein were oxidized first. When fixed tissue sections were oxidized with iodine or H_2O_2, prior to treatment with the reagent (I), the staining reaction was completely eliminated except in the case of elastic tissue. In sections of tissue which were oxidized with iodine, subsequent treatment with 1–10% solution of KCN for 18 hr, or with a 10% solution of $(NH_4)_2S$ for 2 hr, restored the sulfhydryl groups from the oxidized or disulfide state, and in addition produced new sulfhydryl groups by reduction of naturally occurring disulfide groups in the protein. This was indicated by restoration and intensification of staining of the original sites of sulfhydryls after the above treatment, as well as by extension of staining to new areas, even though KCN produces only one sulfhydryl from each disulfide group. The localization of color reaction in this instance was the same as that found by the staining of sulfhydryl groups (*17*)—both free and those derived from disulfides—at pH 11 with the oxidizing agent, ditetrazolium chloride (*18*).

Proof of the specificity of the histochemical reaction for sulfhydryl groups was obtained by the following: 0.1 *M* iodoacetate (24 hr) or 0.1 *M* N-ethyl maleimide[3] (4 hr) completely inhibited the staining reaction and 0.03 *M* glutathione (3 hr) completely reversed the reaction prior to coupling.

The sulfhydryl group of glutathione probably did not contribute to the staining of tissues, since glutathione is completely soluble in acidified 80% alcohol. Insulin is also soluble in this fixative. This may be the reason that pancreatic islet cells showed no increase in intensity of staining when sections of pancreas were treated with $(NH_4)_2S$ or KCN before staining.

Oxidation of protein sulfhydryl groups by atmospheric oxygen did not take place to any appreciable degree during the staining reaction at pH 8.5, since there was no apparent difference between tissue sections stained as described and those stained under anaerobic conditions.

Staining of elastic tissue with this method must be attributed to a special affinity for the naphtholic groups of the reagent and not to sulfhydryl groups, since prior oxidation with iodine did not alter the results. Other derivatives of β-naphthol, particularly 6-bromo-1-naphthol, 2-hydroxy-3-naphthoic acid hydrazide (*10*), and 2-hydroxy-6-naphthalene sulfonic acid, 2-hydroxy-8-naphthalene sulfonic acid, and 2-hydroxy-3-naphthoic acid, also have an affinity for elastic tissue (*17*), although after coupling with a diazonium salt, they do not stain structures where large

concentrations of sulfhydryl groups are known to occur.

Further studies in the distribution of sulfhydryl and disulfide groups and their changes in various physiological states will be published elsewhere.

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Role of Coenzyme A and DPN in the Oxidation of α-Ketoglutaric Acid[1]

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From recent work it has become apparent that diphosphopyridine nucleotide (DPN) and coenzyme A (CoA) participate in the oxidation of α-ketoglutarate (*1–4*). Succinyl CoA has been postulated as an intermediate in the reaction. Using α-ketoglutaric oxidase (*5*) of over 90% purity, as shown by electrophoretic and ultracentrifuge analyses, we have found that the primary reaction is as follows:

$$\alpha\text{-Ketoglutaric acid} + \text{CoA} + \text{DPN}^+ \rightarrow \text{Succinyl CoA} + \text{DPNH} + CO_2 + H^+.$$

For the first time an acylated derivative of CoA has been obtained from the enzymatic oxidation of an α-keto acid.

In the presence of CoA[3] and cysteine (or glutathione or borohydride instead of cysteine), the purified α-ketoglutaric oxidase (*5*) catalyzes the reduction of DPN by α-ketoglutaric acid (Fig. 1). The stoichiometry of the reaction with CoA (Table 1) is consistent with the above equation. The disappearance of —SH group and CoA in amounts equivalent to

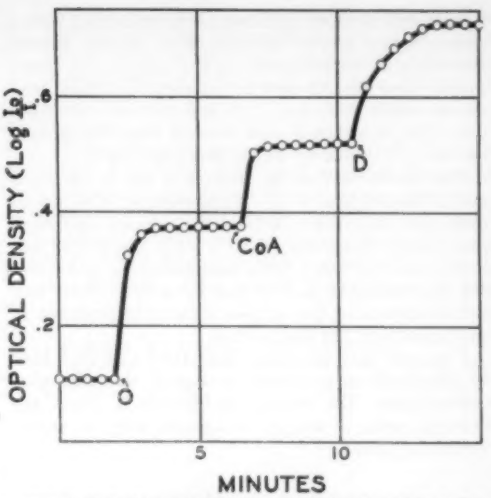

FIG. 1. Reduction of DPN by α-ketoglutarate and CoA. Experimental conditions: cysteine (0.1 ml 0.5 *M* neutralized solution) and CoA (0.1 ml containing 0.3 mg of preparation with an activity of 340 u/mg) were incubated for 3 min at 30°. α-Ketoglutarate (5 μM), DPN (0.3 μM), glycylglycine at pH 7.2 (100 μM), and water to a total vol of 3.0 ml were added to the cysteine-CoA mixture. After 2 min 10 u α-ketoglutaric oxidase in 0.01 ml were added to start the reaction. A mixture of cysteine (0.1 ml) and CoA (0.05 ml) was added at 6.5 min, and purified succinyl CoA deacylase (*4*) at 10.5 min. Optical density ($\log \frac{Io}{I}$) was measured at 340 mμ in a Beckman DU spectrophotometer.

TABLE 1

STOICHIOMETRY OF THE REACTION OF α-KETOGLUTARATE WITH DPN AND CoA*

Expt	Δ α-Ketoglutarate	Δ CoA	Δ —SH	DPN reduced	Hydroxamic acid formed
1	7.0	4.5	—	4.6	4.8
2	2.4	1.5	—	1.4	1.7
3	0.76	—	0.47	—	0.51

* The data are expressed in μM. Three to 7 min after the reaction was started by the addition of oxidase, an aliquot was reacted with hydroxylamine (*6*) for 1 hr. Another aliquot was treated with methanol, and the DPNH determined by the change in optical density at 340 mμ produced by acetaldehyde and crystalline alcohol dehydrogenase. The free sulfhydryl group was determined by the nitroprusside reaction (*7*), CoA by arsenolysis with phosphotransacetylase (*8*), and α-ketoglutarate as the 2,4-dinitrophenylhydrazone (*9*). Cysteine was not present in Expt 3.

formation of acid anhydride[4] (as shown by the reaction with hydroxylamine) suggests strongly that the product is succinyl CoA. As in the case of acetyl CoA (*10*), the anhydride bond appears to be formed between the —SH of CoA and one of the carboxyls of succinate. Succinyl CoA is obtained from the reaction mixture by adsorption on Nuchar C190 followed by

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[2] Postdoctorate fellow of the National Cancer Institute, National Institutes of Health, USPHS.

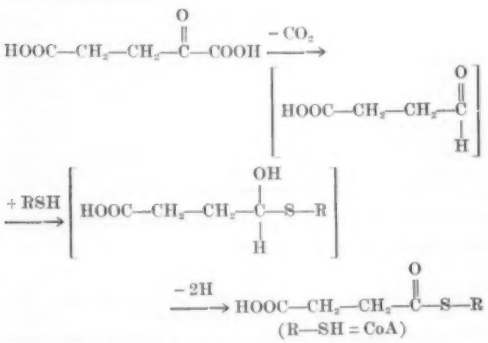
[3] We are greatly indebted to H. Beinert and others for generous gifts of CoA (*J. Am. Chem. Soc.*, **74**, 854 [1952]), which made this investigation possible.

[4] Using S-acetyl-β-mercaptoethylamine as a model, Novelli has presented evidence that thioesters behave like acid anhydrides in that the activated carboxyl reacts with hydroxylamine at acid pH (*1*).

elution with aqueous pyridine, or by extraction with a phenol-benzyl alcohol mixture. The isolated sample reacted with sulfanilamide in the presence of crude pigeon liver acetone powder extract (*3*) under conditions where succinate, CoA, and cysteine were inactive. The hydroxamic acid derived from the sample has been identified by paper chromatography.

The equilibrium of the reaction is far to the right and is independent of pH. Triphosphopyridine nucleotide will not replace DPN in the reaction. Although pantetheine (synthetic LBF) (*11*) is inactive at low levels (1.3×10^{-4} *M*), high concentrations (6.7×10^{-3} *M*) can replace CoA. Protogen B,[5] α-lipoic acid,[5] and boiled extracts of the oxidase containing protogen in coenzyme form (*5*) are inactive.

From the data presented, both DPN and CoA may be considered as prosthetic groups of the α-ketoglutaric oxidase. The reaction mechanism in which the brackets refer to enzyme complexes may be represented as follows:



The initial decarboxylation has been indicated previously (*5*) and is further supported by the rapid incorporation of radioactive CO_2 into α-ketoglutarate in the absence of DPN or CoA (*12*).

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[5] Kindly supplied by T. H. Jukes and L. J. Read.

Direct Determination of Maximal Daily Metabolism of Alcohol

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Not long ago one of us (*1*) estimated that the maximal daily metabolism of alcohol by a man of average weight was represented by a quart of 100-proof liquor. This estimate was based on prolonged feeding experiments in dogs and the demonstrable similarity in the rate of alcohol metabolism in the dog and in man.

In spite of the simplicity of the direct experimental approach to this problem in man, search of the literature failed to reveal any objective information, and for this reason the present work was undertaken. Four subjects were used, three men and one woman. Two were moderate drinkers, and two had drunk to excess sufficiently to classify them as chronic alcoholics. They varied over a wide range as to age and body build. The experimental procedure was essentially the same in all cases. A test dose of 1.0 ml/kg of 95% alcohol diluted to about 20% with water was administered by mouth on an empty stomach, after which samples of venous blood were taken hourly and analyzed for alcohol by a modification of Winnick's method (*2*). From the length of time alcohol remained in the blood the amount metabolized per hour was calculated. Subsequently this amount was administered hourly, either as diluted alcohol or as an acceptable alcoholic beverage, and the blood or saliva alcohol concentration was determined at suitable intervals. To avoid undue inconvenience to the subject, during the night three doses three times the size of the hourly dose were given, which required only two awakenings. The results can best be presented for each individual subject.

Subject 1 was a moderate drinker, male, age 44, weight 61.4 kg, height 168 cm, body surface (Dubois) 1.70 m^2. The estimated hourly dose of 12.0 ml 95% alcohol resulted in 71 hr in a blood alcohol concentration of 17 mg %. Increasing the dose to 15.0 ml resulted in 48 hr in a rise to 159 mg %. According to Widmark's formula (*3*), it can be calculated that this rise in blood alcohol concentration would require 81 ml 95% alcohol; actually the subject received during this time 720 ml. This, less the amount required to produce the rise in blood alcohol concentration, amounts to 639 ml in 48 hr, or 320 ml daily.

Subject 2 was a moderate drinker, male, age 60, weight 65.0 kg, height 173 cm, body surface 1.79 m^2. The estimated hourly dose was 10.0 ml, which resulted in 54 hr in a blood alcohol of 8 mg %. Increasing the dose to 12.5 ml for 51 hr raised the blood alcohol to 91 mg %, which rise would require 52 ml alcohol. The actual amount given, 638 ml, less this excess, amounts to 586 ml in 51 hr, or 276 ml daily.

Subject 3 was a chronic alcoholic, female, age 32,

weight 50.5 kg, height 165 cm, body surface 1.54 m². The estimated hourly dose was 10.0 ml, which in 52 hr resulted in a blood alcohol of 199 mg %. This would require an excess of 93 ml of alcohol; this, subtracted from the amount administered, leaves 427 ml metabolized in 52 hr, or 197 ml daily. Decreasing the dose to 8.0 ml hourly resulted in a drop of blood alcohol of 51 mg % in 59 hr, indicating an excess of metabolism over intake of 24 ml, which, added to the dose administered, gives a total of 496 ml in 59 hr, or 202 ml daily.

Subject 4 was a chronic alcoholic, male, age 39, weight 68.2 kg, height 186 cm, body surface 1.92 m². The estimated hourly dose of 12.5 ml did not cause measurable amounts of alcohol to appear in the blood in 28 hr, so it was raised to 17.5 ml, which in 48 hr raised the blood alcohol to 63 mg %. The amount of alcohol required to produce this rise, 39 ml, subtracted from the amount administered, gives 801 ml metabolized in 48 hr, or 400 ml daily. Further increase of the dose to 20.0 ml hourly raised the blood alcohol an additional 123 mg % in 21 hr, requiring an excess of 79 ml. The amount administered, 420 ml, less this excess, gives 341 ml metabolized in 21 hr, or 389 ml daily.

From the foregoing it can be seen that there is a wide range of maximal daily metabolism in different individuals, varying in our small series from about 200 to 400 ml 95% alcohol. When this is calculated on a basis of body weight the spread is much less, but this is not further reduced when related to body surface, as can be seen from Table 1. Neither can it be related to drinking habits, since the values for the two moderate drinkers lie between the extremes shown by the chronic alcoholics.

TABLE 1

Subject	1	2	3	4
Sex	Male	Male	Female	Male
Alcohol habits	Moderate	Moderate	Excessive	Excessive
Daily metabolism 100-proof liquor (ml)	608	524	383	760
Daily metabolism g alcohol/kg	4.17	3.23	3.06	4.46
Daily metabolism g/m²	151	117	100	158

It seems unlikely that maintaining the average blood alcohol level in a higher range would be effective in increasing to an appreciable degree the maximal metabolism of alcohol. Thus in the case of subject 3, during the first 52 hr the average blood alcohol concentration was about 100 mg % and the amount metabolized daily, 197 ml, whereas during the second period of 59 hr the average blood alcohol was 175 mg % with an almost identical daily consumption of 202 ml. This is in accord with the findings of Cutting, Newman, and Yee (*4*) that there is some increase in rate of alcohol metabolism with increasing blood alcohol concentration, but that this is minor in degree.

In all the foregoing the term metabolism has been used to cover the disappearance of all the ingested alcohol. This is obviously inaccurate, since some is excreted, mainly in the breath and urine, but since this is at most 10% it can for practical purposes be disregarded.

We can thus conclude that administration of alcohol over a period of a number of days has demonstrated a maximum metabolism in our series equivalent to 760 ml of 100-proof liquor, somewhat less than the quart estimated from animal work. No doubt a larger series would show a greater range, but it is unlikely that the quart a day would be significantly exceeded.

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On the Evaluation of the Constants V_m and K_M in Enzyme Reactions

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The Michaelis-Menten theory (*1*) of enzyme action may be expressed by the following equation:

$$E + S \underset{k_2}{\overset{k_1}{\rightleftarrows}} C \xrightarrow{k_3} E + P, \qquad \text{(I)}$$

where E is free enzyme, S is free substrate, C an intermediate enzyme-substrate complex, and P the product of the reaction. Using the same symbols for denoting concentrations, it follows that the reaction rate (v) is at any moment equal to $k_3 \cdot C$. When $S \rightarrow \infty$, the reaction rate approaches a maximum (V_m) equal to $k_3 \cdot E_t$, where $E_t = E + C$. If initial reaction rates are measured, the substrate concentration will remain practically constant during the time of measurement. Further, if $S \gg E_t$, only a negligible amount of substrate can accumulate in the form of the intermediate complex. From this it follows that (a) the concentration of free substrate may be set equal to the total substrate concentration, and (b) the rate of disappearance of substrate equals the rate of formation of product (steady state). Therefore, $k_1 \cdot E \cdot S - k_2 \cdot C = k_3 \cdot C$. By substitution and rearrangement one obtains

$$\frac{(V_m - v)S}{v} = \frac{k_2 + k_3}{k_1} = K_M \text{ (Michaelis constant).} \qquad \text{(II)}$$

Numerically, K_M is equal to the substrate concentration at half-maximum reaction rate ($V_m = 2v$). When $k_2 \gg k_3$, K_M may be set equal to the dissociation constant (k_2/k_1) of the enzyme-substrate complex, and $\frac{1}{K_M}$ then becomes the "affinity" constant.

Equation II can be written in a linear form in the following three ways:

$$\text{(I)}\quad \frac{1}{v} = \frac{K_M}{V_m} \cdot \frac{1}{S} + \frac{1}{V_m};$$

$$\text{(II)}\quad \frac{S}{v} = \frac{1}{V_m} \cdot S + \frac{K_M}{V_m};$$

$$\text{(III)}\quad V_m = v + \frac{v}{S} \cdot K_M.$$

A plot of the variables of such equations is commonly used for estimating the constants from a set of experimental data. Plots I and II were originally worked out by Lineweaver and Burk (*2*). They are used almost exclusively, whereas Plot III has been used only occasionally (e.g., [*3*]). Plot III, nevertheless, has great advantages over I and II. Since to the author's knowledge this has never been shown on a comparative basis, the importance of such plots in enzyme chemistry may warrant this note.

In Fig. 1, each curve represents the same theoretical case of an enzyme-substrate system with a K_M of 10^{-3} and a V_m of 100. The same points, representing equal increments of v, have been plotted according to Plots I, II, and III. In Plot I, the coordinates go to infinity when $S \rightarrow 0$, whereas in Plot II this is the case when $S \rightarrow \infty$. The half-maximum point (dotted lines) lies in both cases to one side of the curve. Experimental data that may have been obtained with about equal accuracy will be overemphasized at low values of v in Plot I and at high values of v in Plot II. The points at the other end of the curve are apt to be underestimated or even neglected. This is statistically unsound.

None of these objections holds for Plot III. Here the curve has a finite and positive intercept with both coordinates. The half-maximum point lies in the middle of the curve, and on both sides of this point equal emphasis is laid upon all data.

Equal emphasis upon all data is of special importance in cases where there is no certainty that only one enzyme is involved, as can be seen on the basis of Fig. 2. Here a system of two enzymes (A and B), acting simultaneously and independently on the same substrate over a wide range of concentrations, is represented by Plot I and by Plot III. The difference in the constants of the two enzyme systems causes a curvature of the resulting lines. In Plot I, however, this curvature can be noticed only at one end of the curve. In the case of an actual experiment, where an experimental error is involved, the points might easily be taken as representing a straight line. The shorter the range of substrate concentrations applied, the better would be the fit. The corresponding constants could then quite erroneously be taken as the constants belonging to a single and hypothetical enzyme system. Similar difficulties would obtain if Plot II were used. The estimation of the constants will be reliable only if both Plot I and Plot II have been used with the same results, and a wide range of substrate concentrations has been applied.

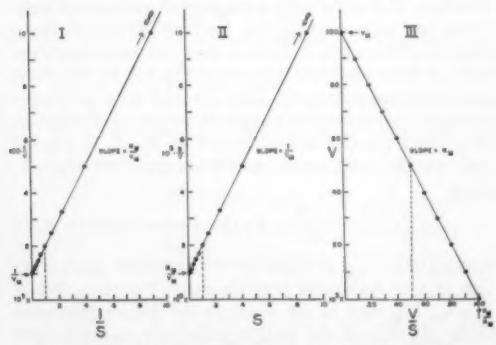

FIG. 1. The three possible linear plots of the Michaelis equation, representing a theoretical case of an enzyme system with $V_m = 100$ and $K_M = 10^{-3}$.

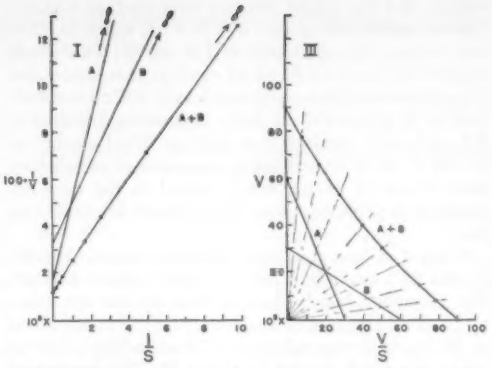

FIG. 2. Theoretical case of two enzymes, A and B, acting simultaneously and independently on the same substrate, with the constants different. The two plots correspond to I and III in Fig. 1. Only in Plot III the resulting line represents a simple addition (along the lines through the origin) of the individual plots.

In Plot III (Fig. 2), no straight line is simulated because enzymes A and B contribute to the curve in direct proportion to the magnitude of the constants. The coordinates of any point on the curve are Σv and $\Sigma \frac{v}{S}$, and the resulting curve is a simple addition of the two individual curves. A line through the origin represents values of v at a particular substrate concentration, and additions and subtractions must be made along such lines.

A situation similar to the theoretical case described above was encountered when a pancreas extract was used as the source of esterase (*4*).

In Plot III (Fig. 1), where V_m is directly given by the intercept with the ordinate, the intercept with the abscissa also has significance. Its value is given by $\lim_{S \rightarrow 0} \frac{v}{S} = \frac{V_m}{K_M}$. In an additive sense, v becomes negligible with respect to V_m at low substrate concentrations. From the original equation, it follows then that under such conditions v may be set equal to $\frac{V_m}{K_M} \cdot S$.

The intercept with the abscissa is therefore the reaction constant of the first order reaction that is approximated at low substrate concentrations.

Under physiological conditions, where the substrate concentration may be low, the reaction rate will be determined by $\frac{V_m}{K_M}$, in which expression $\frac{1}{K_M}$ is related to the affinity of the substrate for the enzyme. In this respect comparison of the rates at which two substrates are attacked has little meaning if only one arbitrarily chosen substrate concentration has been used. It is clear from the above that the complete concentration curves must be determined. If these curves cross, the situation at relatively high concentrations may be the reverse of that at low concentrations. In view of these considerations, the intercept with the abscissa, when Plot III is used, may give directly the most important constant of an enzyme system. In terms of Equations I and II, this intercept equals $\frac{k_3}{K_M}$ or $\frac{k_1 k_3}{k_2 + k_3}$ per amount of enzyme.

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Manuscript received April 1, 1952.

Inhibition of Methylcholanthrene Carcinogenesis by Hypophysectomy[1]

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The significance of pituitary function in neoplastic disease is indicated by the many and diverse neoplasms that develop in the rat following the prolonged administration of growth hormone (*1–4*) and the absence of both growth hormone–induced and spontaneous tumors in the hypophysectomized rat (*5*). The present report is concerned with the inhibitory effect of hypophysectomy in methylcholanthrene carcinogenesis.

For this study 60 adult female rats of the Long-Evans strain were divided into four groups and treated as follows: (1) 15 rats were implanted with methylcholanthrene pellets into the right gastrocnemius muscle; (2) 15 rats were maintained without treatment as controls; (3) 15 rats were hypophysectomized; two weeks following hypophysectomy methylcholanthrene pellets were implanted into the right gastrocnemius muscle; (4) 15 rats were hypophysectomized and maintained without further treatment as controls. All animals were weighed and examined for tumors every 5 days for a maximum period of 316 days.

During the period of observation it was noted that 12 of the 15 rats treated with methylcholanthrene developed a palpable increase in connective tissue at the site of implantation as early as 3½ months and that 8 of these developed rapidly growing tumors after periods varying from 195 to 299 days following the implanting of methylcholanthrene. Prior to the completion of the experiment it was necessary to sacrifice 4 of these animals because of large tumors. Histologic examination of these tumors showed all of them to be sarcomas arising in skeletal muscle.

None of the normal controls developed comparable lesions.

Of the group of 15 hypophysectomized rats treated with methylcholanthrene, only one developed a sarcoma at the site of implantation. There was little or no connective tissue reaction to the methylcholanthrene pellet in the others. Nine of this group survived for more than 199 days, and of these there were 6 which survived for the total experimental period of 316 days.

There were no tumors in the hypophysectomized control group.

Although the numbers of animals used in these experiments are not great enough to warrant a definite conclusion at this time, nevertheless it is considered that the results are sufficiently important to deserve a preliminary note. Additional animals subjected to identical, as well as similar, conditions are now being investigated, following which studies a final report will be made.

[1] Aided by grants from the U. S. Public Health Service, GG409(C3) and C 1098, and the University of California Cancer Grant.

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Manuscript received May 5, 1952.

Comments and Communications

Mitochondria or Microorganisms?

A PAPER by U. N. Lanham, entitled "Observations on the Supposed Intracellular Symbiotic Microorganisms of Aphids," contains some interesting observations of a preliminary nature (*1*). However, the facts reported do not warrant the statement that "the aphid particles lack DNA, and . . . they are not microorganisms." Failure to obtain certain staining reactions generally characteristic of DNA does not prove that a particular object of microscopic dimensions is not a microorganism. Certain stages of the erythrocytic cycle of malaria parasites do not show any structures that give the Feulgen reaction (*2*), although the reaction can be brought out if the malarial pigment is first removed (*3*). Even under the latter conditions, the chromatin stains very faintly in large trophozoites and in gametocytes. A similar negative or barely visible Feulgen reaction has been noted in certain insect oocysts (*4*), cells which nevertheless almost certainly contain DNA. It is possible that the symbiotes of aphids exhibit different staining reactions at different stages of their developmental cycle.

Especially important in the demonstration that certain insect symbiotes are undoubtedly symbiotic microorganisms have been the researches of A. Koch (*5*), M. Blewett and G. Fraenkel (*6*), and N. C. Pant and G. Fraenkel (*7*). These workers have shown that several species of beetles which contain yeastlike symbiotes are able to grow on diets deficient in certain vitamins, whereas the same species, if experimentally deprived of their symbiotes, require these vitamins in their diet. Moreover, two of the species of symbiotes have been grown in culture, and the cultures have been used to infect symbiote-free insects.

Certainly much remains to be learned as to the nature and function of the intracellular symbiotes of aphids and related insects. Equally certainly, more than microscopic observations on one species of aphid will be needed before definitive conclusions can be drawn.

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A NEGATIVE result, such as failure to demonstrate the presence of a given substance, is, of course, usually unsatisfactory, and although such a result might lead one or another investigator to the conclusion that the substance in question is really absent, it cannot be regarded as affording absolute proof. The comments by Dr. Trager on the difficulties of staining *Plasmodium* by the Feulgen technique are not strictly relevant, since the conclusions in question were based on the use of acid-Giemsa; but it is quite possible that Giemsa would also fail in this instance. Certain bacteria also are reported to have nuclei resistant to acid-Giemsa, although with some of these (including *Azotobacter*) I have had little difficulty in obtaining densely staining internal structures of some kind, following fixation of dry films in absolute methyl alcohol.

The example of the microorganisms of beetles (*Stegobium* and *Lasioderma*) studied by Koch and others may or may not be relevant to the aphid problem. These microorganisms are said to be transmitted from one generation to another on the eggshells, which have to be eaten by the newly hatched larva. Nothing like this occurs in aphids, in which a cytoplasmic mode of transmittal has been postulated. Also, the beetle microorganisms are found free in the digestive tract; or, when intracellular, the host cells are associated with the digestive tract. There is no conclusive evidence of extracellular occurrence of the aphid particles, and the cells containing them ("mycetocytes") have nothing to do with the digestive tract. Studies of intracellular "microorganisms" in insects have suffered from a certain amount of uncritical jumbling together of unrelated evidence from diverse groups of insects, or even from protozoans and leguminous plants, when this seemed expedient.

In aphids, it seems well established that every individual, of every species, has "mycetocytes" that are packed with the particles in question. From the biological viewpoint, the hypothesis that they are symbiotic microorganisms seems to be a more unlikely, difficult, and complex one than the hypothesis that they are intracellular particulates of the nature of mitochondria. The reasons for assuming the more complex hypothesis to be true from rather early in the history of the subject, and for placing the burden of proof on those holding the simpler hypothesis, can be discussed adequately only by a detailed analysis of the literature of microbial symbiosis in both animals and plants.

The conclusion that the intracellular particles of aphid "mycetocytes" lack DNA and are therefore not microorganisms, reached on the basis of the previously mentioned negative evidence, should also be considered in the light of the following estimate of the major points of the controversy: (1) The aphid particles look like microbes when stained with the older standard stains. It should be noted, however, that when techniques are available which bear critically on the problem, such as the acid-Giemsa

technique, the evidence from staining is, at least so far, negative. (2) Proponents of the microbial theory can point out that the aphid particles do not resemble classical mitochondria because of their stability and their size. However, the studies of Watanabe and Williams (*J. Gen. Physiol.*, **34**, 675 [1951]) on the sarcosomes of insect flight muscles disclose another type which approaches the stability and size of the aphid particles. (3) The aphid particles are supposed to be added intact to the developing egg from the "mycetocytes" of the parent, so that the egg can be regarded as being infected by exogenous microorganisms. But if one examines the critical review of, and careful original work on, the subject of the ontogeny of the "mycetocytes" by Uichanco (*Philippine J. Sci.*, **24**, 143 [1924]), one will find no direct or conclusive evidence for the continuity of the particles of the parental mycetocytes with the particles that suddenly appear in the developing egg or embryo in the oviduct. (4) The aphid particles are said to have been grown *in vitro*. All such claims need verification. Some reportedly successful experiments involve very simple techniques and can easily be repeated. My own attempts to cultivate them, including the use of hanging drop techniques where individual particles could be observed, were not successful.

If the aphid particles are cell particulates, mitochondrial in nature, the question is raised as to the function of cells apparently containing little more than mitochondria. These cells are intimately associated with the fat body in aphids, and what are possibly similar cells in some other insects are also imbedded in the fat body. Since mitochondria are centers of Krebs cycle activity, it might be tentatively postulated that there is a division of labor among the cells of the fat body, certain cells ("mycetocytes") being primarily responsible for providing the energy for the synthesis of fats, proteins, and glycogen, with the typical fat cells being responsible for the storage of these materials. Present work on the particles of the "mycetocytes" of aphids and other insects is exploring this possibility. The presence of Krebs cycle enzymes in the particles would not, of course, directly disprove the microbial hypothesis. The presence or absence of DNA appears to be the most critical question in this respect, and I feel that until someone can show conclusively that the particles contain DNA granules or nuclei, they should be regarded as cell particulates rather than as microorganisms.

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Book Reviews

Botany of Sugarcane. C. van Dillewijn. Waltham, Mass.: Chronica Botanica; New York: Stechert-Hafner, 1952. 371 pp. $6.00.

A comprehensive new book of value to sugar technologists and cane growers alike has been produced by Dr. van Dillewijn, formerly director of the Sugar Experiment Station, Cheribon, Java. The title page appears to suggest that the book is part of a series in preparation, or proposed, entitled "Handbook of Sugarcane." Volume I, *Botany of Sugarcane*, is devoted to the structure, growth, and physiology of the sugar-cane plant, with emphasis on the application of scientific studies to crop production. Chapters 1–6, inclusive, comprise a richly illustrated description of the outer and inner morphology of sugar cane, with separate discussions of the stem, bud, leaf, flower, and root and an evaluation of the characteristics useful in identification of sugar-cane varieties. Sources used by Dr. van Dillewijn in preparing this portion of the book consist of the published records of specialists from late in the past century to the most recent years.

Section II, under the general heading "Physiology," contains chapters on germination, tillering, growth, vegetative composition, chemical composition, nutrition, water relations, photosynthesis, and respiration.

For cane growers without access to the large volume of technical literature on sugar cane this book will provide in compact form an excellent, up-to-date, and full account of research on the biology of sugar cane. Of special interest are the careful descriptions of root development and tillering and the progressive development of ratoon crops after the plant cane crop is harvested. For the first time in a sugar-cane handbook space is given to the important growth-regulating substances. The whole treatment of growth processes contains much that is useful in practical manipulation of the crop. The chapters on nutrition and on water relations similarly present fundamental information on fertilizer and water requirements and the interrelation of these factors as they influence growth and sugar production. There are 617 references to technical literature.

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Short-Wave Radiation Phenomena, Vols. I and II. August Hund. New York–London: McGraw-Hill, 1952. 1382 pp. $20.00 the set.

It is not always easy to formulate a concrete opinion about a book of such tremendous proportions as this 1382-page opus. In the present case, this is even more difficult because it is hard to identify the reader to whom the work might have been addressed. It is cer-

tainly not useful for a college student who meets such subject matter for the first time, for the work is much too detailed. Neither is it for the specialist, who does not need the mass of detailed computation to orient him in a specific problem. Nor is it, finally, a comprehensive introduction to the subject of "short-wave radiation phenomena," for no modern book on the subject can afford to devote but two pages in its entire length to horns and only about one page to metal-lens antennas. Such disregard for the value of modern radiating systems might have been fully justified in a text largely devoted to important theoretical aspects of the subject, leaving no space for discussion of practical problems. No such lack can justly be claimed as an excuse, as a large amount of space is wasted in actual arithmetic, trivial trigonometric relations, and extensive numerical examples occupying page after page.

Perhaps there will be a group of readers who will appreciate having as a permanent reference the minute examination of the problems of reflection, refraction, and diffraction. These subjects occupy about half of Volume II. Here one finds, in the problem of radiation in free space, the detailed examination of reflection and refraction of plane waves in passing from one isotropic medium into another. The examination of this problem, with arbitrary angles of incidence, requires 8 pages of general discussion and 27 pages of tabulated calculations and discussion. This is then followed by some 150 additional pages of discussion of related topics, such as calculation of Brewster's angle for various conditions, magnitude and phase of reflections from the earth, and calculation of field patterns from simple radiators in the presence of a reflecting medium. Each of these is considered in great detail and should be of value to anyone to whom the specific problems happen to be important.

The subject of electromagnetic diffraction is also discussed in considerable detail, starting with the usual basic principles—i.e., Huygen's principle, Fresnel wave interference, and other matters usually taken up in a course in physical optics. These are applied to the study of parabolic electromagnetic radiators, wave propagation through apertures, diffraction from sharp edges, diffraction around a spherical earth, etc., each case being considered thoroughly and completely. Here the book is at its best, and the reader will find the matter well presented, with numerous references to the original works in the field.

The first volume is divided as follows: Chapters I, II, and III present the fundamental concepts and relations of currents and electromagnetic fields, occupying a space of 360 pages. In their scope, they represent a standard introduction, containing the required elements of the theory of electricity and magnetism for the study of radiation phenomena. Chapter IV, entitled "Propagation Characteristics," discusses the properties of the propagation constant in unbounded and guided space, including such topics as phase, group, and signal velocities and cutoff frequency for waveguides. Chapter V discusses transmission line problems, starting with the usual formulas, impedance matching with stubs, and suggests the use of acorn tubes for standing-wave detector probes. It concludes with problems of radiation from transmission lines. Chapter VI deals with the problem of free-space radiation. This can be considered as the first chapter on radiation phenomena, with the preceding 528 pages being more or less preparatory material. In this 255-page chapter one meets the classical problems of radiation from simple dipoles and combinations of such dipoles in radiating arrays. As can be seen from the number of pages devoted to this, the discussion is quite detailed. Chapter VII is concerned with radiation in presence of "obstructions," such as the ground. Chapter VIII is the chapter on diffraction, mentioned earlier. Chapter IX contains 60 pages on waveguides and cavities, being rather brief, with completely standard material. It is doubtful if one would have any reason to prefer this chapter to any of numerous and well-known references on the subject.

As a whole, the book leaves much to be desired. In spite of its bulk, it covers but a small fraction of the important problems of interest today. The superfluity of numerical details is oppressive and does not make it easy to understand the basic problems. In no sense can it be construed to be a "modern" treatise on the important subject of short-wave radiation.

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Scientific Book Register

The Scientists Look at Our World. The Benjamin Franklin Lectures of the University of Pennsylvania, fourth series. John M. Fogg, Jr., Ed. Philadelphia: Univ. Pennsylvania Press, 1952. 147 pp. $3.00.

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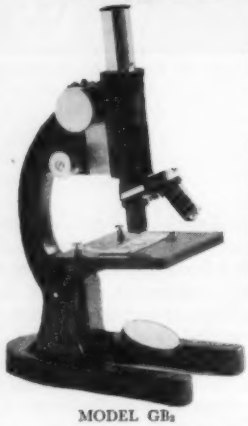

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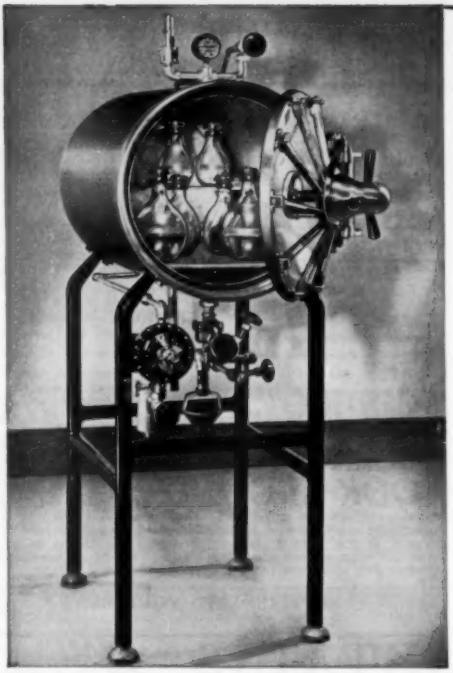

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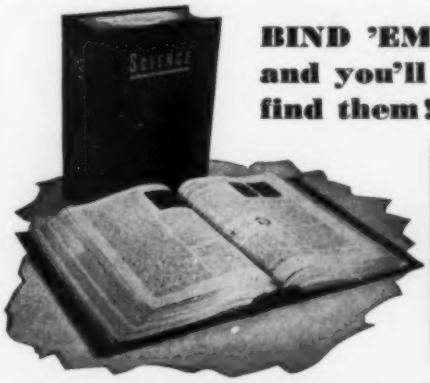

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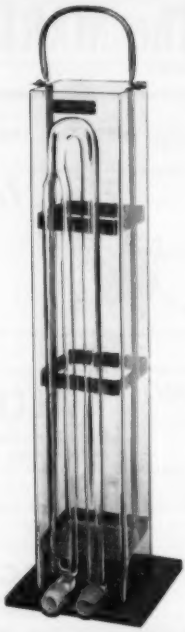

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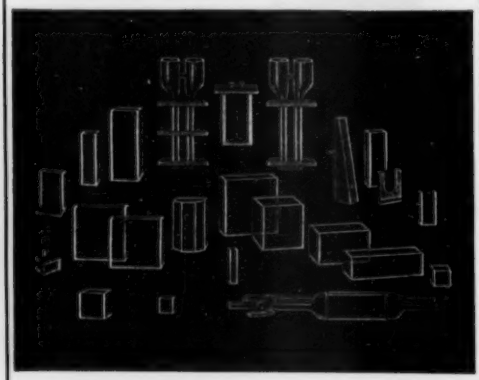

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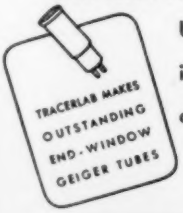

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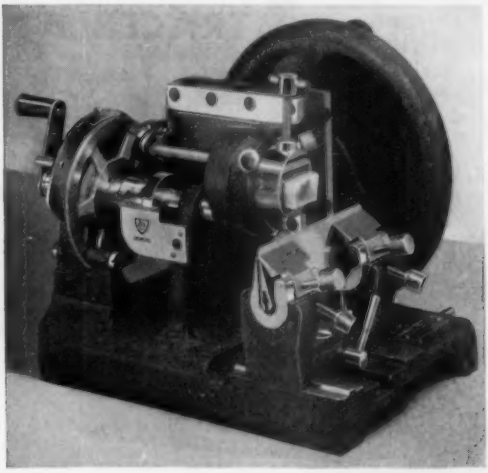

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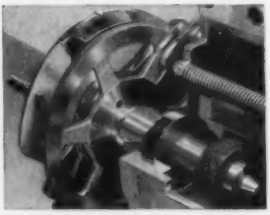

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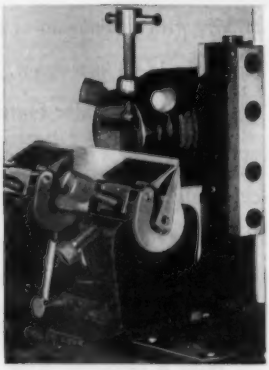

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